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ENGINEERING:

An Illustrated Weekly Journal.

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...for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
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AUTOMATIC FEED REGULATORS.
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Great saving of labour. No noise No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4535

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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817

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See Advertisement page 71.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } ROW'S PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
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IRON & STEEL
Tubes AND Fittings AND Steel Plates.

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See Advertisement, page 98. 1111

Drag Line Excavator.
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
HARRY FAIRCLOUGH, Contractor, WARRINGTON. 1550

Unique Opportunity.
FOR SALE, at CONSIDERABLY REDUCED PRICES, a Number of
New Electric Portal Harbour Cranes,
Capacity 3 tons and 1½ tons, at maximum radius 54 ft.
Built to a first-class Colonial Specification.
Ready for IMMEDIATE DELIVERY, including spare parts.
Full particulars on application.
Address, C 212, Offices of ENGINEERING.

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Works; BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
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Combined Circulating and Air Pumps.
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&c., &c. 1586

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HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

GEARS OF EVERY DESCRIPTION.
AUTOGEARS (LEEDS), LTD., Spring Grove, Hyde Park Road, Leeds. 1743

Carels Diesel & Steam Engines. 1120
CARELS DIESEL & STEAM ENGINES (LONDON) LTD., Kinnaird House, 1, Pall Mall East, S.W. 1. Telephone: Regent 3484.

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Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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See Advertisement page 56. Nov. 30 2403

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Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
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National Gas Engine Sets, with Producer Plants, Two 125 Kw., 220 volts., and Two 300 Kw., 500 volts. Several others.
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Railway Switches and Crossings.
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For Your Repairs or any SPECIAL MACHINERY, try THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Nat 1854. 1792

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54 & 55, FETTER LANE, LONDON, E.C. 4.
62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

HEAT INSULATION.
CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Nov. 16.

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.H.P. and upwards
Petters Limited, Yeovil.
Sizes 25 to 500 B.H.P.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9235

Centrifugals.
Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 1676
See half-page Advertisement, page 68, Nov. 23.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

PATENTS AND DESIGNS ACTS, 1907 & 1919.

Notice is Hereby Given, that

Svenska Aktiebolaget Gas Accumulator, a Swedish Company, and Gustaf Dalin, a Swedish subject, Managing Director of the said Company, both of Lidingön, 8½ miles, near Stockholm, Sweden, seek leave to amend the Specification for Letters Patent No. 203255, entitled "Improvements in or Relating to Porous Masses for Storing Explosive Gases."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 21st November, 1923.

Any person or persons may give notice of Opposition to the Amendment by leaving Patents Form No. 19, at the Patent Office, 25, Southampton Buildings, London, W.C. 2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. C 329

Correspondence Courses for

Inst.C.E., Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Examinations.—

Day, Evening or Correspondence Courses of Preparation for all examinations. Thousands of successes during the past eighteen years.—G. P. KNOWLES, M.B.E., B.Sc., A.M.I.C.E., etc., 39, Victoria Street, Westminster, S.W.1. C188

TENDERS.

METROPOLITAN BOROUGH OF ISLINGTON.

The Council of the above Borough invite

Tenders for the Supply and

ERECTION of a 5000 KILOWATT TWO-PHASE TURBINE ALTERNATOR, CONDENSING PLANT, CONDENSATE, CIRCULATING, EXHAUST, STEAM and WATER PIPES and OTHER ACCESSORIES.

Specification, General Conditions and Form of Tender may be obtained on application, in writing, to the Electrical Engineer, 6a, Eden Grove, Holloway, London, N. 7, on or after Friday, December 14th, 1923.

Tenders, under seal, endorsed "Tender for Electrical Plant," must be delivered to the undersigned, not later than Noon, on Thursday, January 17th, 1924.

By Order,
C. G. H. FLETCHER,
Town Clerk.

Municipal Offices,
Tyndale Place, Upper Street,
London, N. 1.
3rd December, 1923. C 317

COUNTY COUNCIL OF DURHAM.

TO STEEL BRIDGE ENGINEERING CONTRACTORS.

The County Council of Durham invite

Designs and Tenders for the

SUPPLY and DELIVERY and ERECTION (optional) of a number of STEEL GIRDER ROAD BRIDGES on prepared abutments.

Full particulars and conditions, together with copies of site and abutment drawings, may be obtained from the Office of the undersigned on deposit of the sum of £2 2s., which will be returned on receipt of a *bona fide* Design and Tender.

The County Council do not bind themselves to accept the lowest or any Tender.

Sealed Designs and Tenders, duly endorsed, to be delivered to the undersigned as soon as possible but, in any case, not later than the 31st December, 1923.

ALBERT E. BROOKES, M.I.C.E.,
County Engineer and Surveyor.

County Surveyor's Office,
Shire Hall, Durham.
4th December, 1923. C 340

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED

are prepared to receive

Tenders for the Supply of :—

One 40 Ton LOCOMOTIVE HOIST.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Locomotive Hoist," must be left with the undersigned not later than Twelve Noon on Friday, the 4th January, 1924.

The Directors do not bind themselves to accept the low-st or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of the Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

W. B. REYNOLDS,
for Managing Director.

4th December, 1923.
91, Petty France, S.W.1. C 343

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for :—

1.	POINTS and CROSSINGS, &c. ...	Fee 10/-
2.	FIREBRICKS	,, 5/-
3.	BELLOWS	,, 2/6
4.	STEELWORK for BRIDGES ...	,, 10/-
5.	SPARE PARTS of CARRIAGES and WAGONS (BUFFERS) (i)	,, £1

Tenders are due by Eleven a.m. on 18th December, 1923. Tender forms obtainable at above address. FEES NOT RETURNABLE. C 342

THE MINISTRY OF PUBLIC WORKS, EGYPT, are calling for

Tenders for the Supply and

ERECTION of a PUMPING PLANT to replace an existing steam plant at Qassassin. The contract will include the dismantling and removal of the existing plant. Firms quoting must send their Tenders direct to Egypt, where they are due 5th February, 1924.

Forms and Specifications, price 10/-, can be obtained at the Office of THE INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, S.W.1. C 360

GAINSBOROUGH URBAN DISTRICT COUNCIL.

WATERWORKS.

Engine and Pumping Plant for Borehole.

The Council invite

Tenders for the Above Engine

and PUMPS for raising water for the Town's supply from Artesian Borehole.

Plan of the Engine House and site, section of Borehole with Specification, Form of Tender and general particulars will be supplied upon application to S. W. PARKER, Waterworks Engineer, Council Offices, Gainsborough.

Tenders to be enclosed in a sealed envelope endorsed "Tender for Waterworks Pumping Plant" to be delivered or forwarded to the Clerk to the Council, Council Offices, 6, Lord Street, Gainsborough, on or before Monday, the Eleventh day of February, Nineteen hundred and twenty-four.

A deposit of Two Guineas must accompany application for "Form of Tender," plan, specification, etc., and the deposit will be returned upon receipt of a *bona fide* Tender.

The Council do not bind themselves to accept the lowest or any Tender.

Signed,
H. P. MORGAN,
Clerk to the Council,

Council Offices,
Gainsborough.
4th December, 1923. C 333

COUNTY OF LONDON.

ROTHERHITHE TUNNEL.

The London County Council invites

Tenders for the Construction

of a ROOF of STEEL and GLASS and of a MACHINERY PLATFORM of STEEL GIRDERS and CONCRETE in No. 1 Shaft, Rotherhithe Tunnel.

Persons desiring to submit Tenders may obtain the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council, at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 7th January, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. C 356

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

Contract No. 17—New Intake.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the CONSTRUCTION of an INTAKE and SCREENING HOUSE, a 5 feet diameter CONDUIT, and ancillary Works alongside the River Dee at Cairnton, Invercannie.

The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 4th December, 1923, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no Specification will be given out after 13th December.

For each specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.

The employment of labour shall be in accordance with conditions of the Unemployment Grants Committee.

Tenders on the forms prescribed, and enclosed in securely sealed envelopes, endorsed "Tender for New Intake" are to be addressed to the undersigned. No Tender delivered after Five p.m. on 26th December, 1923, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

No person should Tender unless thoroughly experienced in the actual construction of extensive public works.

GEORGE MITCHELL, M.Inst.C.E., F.G.S.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
30th November, 1923. C 363

APPOINTMENTS OPEN.

The Stanton Ironworks Com-

PANY, LIMITED, near Nottingham, REQUIRE the SERVICES of a FOUNDRY WORKS MANAGER.—Apply, in writing, enclosing photograph, to the FOUNDRY GENERAL MANAGER. C 304

Wanted, Export Sales

MANAGER, one used to Compressed Air and Pneumatic Tools preferred. Good linguist.—Address, C 354, Offices of ENGINEERING.

Secretary-Cashier Required

for Engineering Works near Leeds, must be energetic and have initiative and be able to take charge of correspondence and control staff. Age 30—0. Replies stating age, experience and salary required.—Address, C 359, Offices of ENGINEERING.

BIGGLESWADE WATER SUPPLY.

MECHANICAL ENGINEER.

THE BIGGLESWADE WATER BOARD and the BIGGLESWADE RURAL DISTRICT COUNCIL invite

Applications from Persons

who have been trained as Mechanical Engineers for the APPOINTMENT of SUPERINTENDENT OF THE WATERWORKS.

The Person to be appointed must not exceed 35 years of age and will have to devote the whole of his time to the duties of his office, particulars of which can be obtained from the Clerk to the Authorities.

Salary £350, increasing £25 per annum up to £450 and an allowance of £30 per annum for travelling if a Motor Car or Motor Cycle is used.

Applications, stating age and particulars of the candidate's career, with copies of three testimonials, must be delivered to the undersigned at his Office at Biggleswade, Beds, on or before the 15th December next. Canvassing not allowed.

HENRY CHAUNDLER,
Clerk to the Biggleswade Water Board and the Biggleswade Rural District Council. C 255

Wanted, Aircraft

EXAMINERS for Aeronautical Inspection Department. Only Ex-service candidates will be considered. Applicants must pass Ground Engineer's Examination, Category B or D; must have previous experience examination aircraft metallic and non-metallic materials, detail parts, manufacturing processes and assemblies; sound elementary knowledge mathematics, machine drawing, applied mechanics, including strength of materials; and previous workshop experience in engineering or allied trades. Salary £320 p.a.

Apply, SECRETARY AIR MINISTRY (D.D.A.I.), Alexandra House, Kingsway, W.C.2, stating experience, ex-service qualifications, &c. C 344

The Royal Air Force

REQUIRES SKILLED FITTERS General (for training as Aero Engine Fitters), Fitters Driver Petrol, Electrical Fitters and Power Station tradesmen. Age limits:—Ex-Service men 18 to 30; Non-Ex-Service 18 to 26; highly skilled Fitters up to 35. Ex-N.C.O's up to 38 years (with rank according to trade ability). Pay from 24s. 6d to 66s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, W.C.2. B 759

An Old-established Company,

at present doing a large business with Railways and Locomotive Builders, DESIRE to obtain the SERVICES of a GENTLEMAN having entree to Locomotive Engineers and Railway Purchasing Departments, for the purpose of further developing their sales. Ex-Railway Official preferred. Liberal salary and commission.—Write, stating past experience, qualifications, &c., BOX 759, SELL'S Advertising Offices, Fleet Street, E.C. 4. C 330

Engineer Salesman Required

by important Machine Tool Concern, to sell all kinds of heavy machine tools to railways & shipyards. Excellent personal connection with buyers essential. Give full particulars of technical and sales experience and state salary.—Reply, BOX 87, MATHER & CROWTHER, LTD., New Bridge St., London, E.C. 4. C 302

SOUTH AFRICAN RAILWAYS' ELECTRIFICATION.

Applications are Invited for

the following position :—

ASSISTANT ELECTRICAL ENGINEER, to supervise the erection of the Electrical Equipment of the Power Station at Colenso. Experience in the erection of large-capacity switchgear essential. Salary £600 a year, passage from England and 18 months' engagement.

Applications, by letter only, with copies of testimonials, marked "Power Station," stating name, age, education, engineering training and details of practical experience, must be received by Messrs. MERZ & MCLELLAN, 33, Victoria Street, LONDON, S.W. 1, not later than 14th January, 1924.

Applications from candidates in South Africa should be submitted to Messrs. MERZ & MCLELLAN, c/o The General Manager, South African Railways and Harbours Administration, Johannesburg, not later than 24th December, 1923. C 303

Wanted, a Capable Young

ENGINEER of good address, to represent an important firm and push sales. Preference given to one who has a good acquaintance with Industrial engineering and some previous experience in interviewing firms to obtain orders.

Address, ALPHA, WM. PORTEOUS & Co., Advertising Agents, Glasgow. C 307

Waterpower Engineer

QUIRED, accustomed to ... proposals and prepare estimates for ... power plants.—Apply, by letter only, ... experience and salary required, to JAMES ... AND Co., LTD., Windsor House, Kingsway, W.C. 2.

Engineer, Assist

A.M.I.C.E., with railway ... WANTED for maintenance permanent way Railway. Salary £550.—Write, BOX 96 ... WAIT & SIMMONS, 34, Throgmorton Street, ...

Civil Engineer, J

REQUIRED for contracts in tropics, ... age 25. Sound constitution essential.—W ... 118, c/o DAWSONS, 17, Craven Street, Londo...

Required by Engine

Firm in the North of England, ... CAL ENGINEER with experience in the ... Heavy Duty and Traction Motors.—Addres... full particulars of qualifications, experi... salary required, C 349, Offices of ENGINEER... applications will be treated with strict con...

Assistant Engi

REQUIRED by the GOVER... of the GOLD COAST for Railwa... for a tour of from 12 to 18 months' service... £600 rising to £720 a year by annual incre... £30, and thence to £920 a year by annual in... of £40. Outfit allowance of £80 on first appo... Field allowance of £90 a year will be pa... actually performing the duties of the offi... Colony. Free first-class passages. Liberal ... home on full salary. Candidates, not over ... of age, must be proficient in the use of the ... Theodolite and Level. Must have a know... methods of running in curves and other ... pertaining to Railway Location. A theoreti... ledge of Topography is essential, and ... methods of obtaining the information and ... to which it is applied. Must have the abili... ordinary draughting and compiling esti... Apply, at once in writing, giving brief ... qualifications and experience and stating ... THE CROWN AGENTS FOR THE COL... 4, Millbank, Westminster, S.W.1, quoting ...

Wanted, Engineer-Drau

MAN with experience of Dock and ... Work and the preparation of plans for sa... not over 35. Applicants should state age ... required, giving particulars of experien... training in surveying and the prepara... drawings.—Address, C 297, Offices of ENGIN...

Draughtsman and Desi

WANTED by a large firm of gas stov... facturers in Midlands. First-class experi... light casting industry, modern Engl... drawing office practice and workshop ... essential. — Address, stating age, salary e... and fullest details of experience, C 335, O... ENGINEERING.

First-Class Rolling S

DRAUGHTSMAN REQUIRED, ex... in Bus and Tramcar Bodies essential.— ... stating age, experience and salary required ... BRUSH ELECTRICAL ENGINEERING Co... Loughborough.

Draughtsman Want

thoroughly experienced in the de... Colliery Electric Winding Engines and ... Gears (Mechanical portions). State age, exp... and salary required.—Address, C 338, Of... ENGINEERING.

Senior Draughtsman Wan

with experience in Corliss and Dro... Engines and Steam Power Plants generally; ... ledge of Uniflow Engines and Colliery W... Engines an advantage.—Address, stati... experience and salary expected, C 361, Of... ENGINEERING.

First-class Draughts

WANTED, with recent experience ... Design of Uniflow and Heat Extraction ... Engines. State age, full particulars of exp... and salary required.
HICK, HARGREAVES & CO., LTD., Sob... Works, Bolton.

Three Senior Draughts

REQUIRED with experience in the ... of :—

(1) Gas Producers and Bye Product Re... Plant.
(2) Oil Refinery Plant.
(3) Conveyors, Elevators and structura...

London District.—Write, stating age, expe... references and salary required, BOX 761, ... Advertising Offices, Fleet Street, E.C.4.

Chief Assistant Draughts

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THE ELECTRICITY SITUATION IN LONDON.

THE co-ordination of the electricity supply of London is not one of those problems which can be relied on to solve themselves if left alone. Its difficulties and complexities increase rather than diminish with lapse of time, and it has become a matter of urgency to find a solution which will bring about future development upon efficient and systematic lines, so that the Metropolitan area may have a supply of electricity worthy of the greatest centre of population in the world. It is useless now to deplore the parochial ideas and the absurd legislation of the last century which have resulted in some seventy different authorities for the County of London alone, each with its own undertaking inaugurated regardless of the nature of the current, the voltage or the periodicity supplied by its neighbours, with whom it was prohibited from co-operating. The appointment of the Electricity Commission in 1919 raised hopes of some sort of unity of control being established which would ultimately result in a definite policy of development, but although a certain measure of success has attended the Commissioners' efforts to co-ordinate the work of electrical undertakings in other parts of the country, the situation, so far as London is concerned, is still in a state of confusion.

The London and Home Counties area, as defined by the Commissioners for the purposes of unity of electrical administration, extends roughly from Hertford in the north to Guildford and Sevenoaks in the south, and from Windsor in the west to Gravesend in the east. It includes the City of London, the twenty-eight Metropolitan boroughs and more or less of the five counties surrounding Middlesex. The complexity of the problem of unification is extreme not only from the technical point of view but also because of the legal rights of the parties concerned. Under the London Electricity Supply Acts the London County Council has the power to purchase the whole of the company undertakings in the County in 1931, and every undertaker in the area, including the London County Council, is under the control of the Electricity Commission in so far as any extensions to plant or mains are concerned. The right of purchase by the County Council does not extend to the large Power Companies, such as the Metropolitan and the North Metropolitan, which are constituted under different Acts of Parliament, nor does it affect municipal undertakings, although its power to refuse loans for extensions of the latter gives it a certain measure of control.

The ultimate object of the Electricity Acts of 1919 and 1921 was to constitute for the London area, as for other areas in the country, a body called a Joint Electricity Authority, who should purchase the whole of the generating stations in the area, and sell current wholesale to the companies and municipalities, who would distribute it and retail it to their consumers. The Joint Electricity Authority would be composed of men fairly representative of the present authorised undertakers, whether company or municipal, and large consumers would also be represented on it. This arrangement would place all generating stations under a unified control, so that those which, by reason of their location or equipment, cannot generate efficiently could be shut down and their load transferred to such as are more favourably situated. The average cost of production would thus be lessened with corresponding benefits to the public, and a greater margin of profit would be available on the capital sunk in transmission and distribution systems. The underlying idea is a sound one, and if it could be carried out in practice, it would undoubtedly have the effect of reducing the situation to something like order. But conditions in London have gone so far that the practical application of such a scheme of unification as we have outlined appears at present to be impossible. The evil that our legislators do lives after them, and we are faced with a situation, in the London area particularly, which so far has baffled all attempts at wholesale correction.

One of the factors overshadowing the present situation is the power to purchase the companies' undertakings which is at present held by the London County Council. This power can be exercised in 1931, or at any subsequent period of ten years thereafter, a notice of three years having previously been given. The County Council has no power to pick and choose. If it purchases at all it must take the whole of the property of every company in the area at the same time. This would involve the raising of a loan amounting to many millions of pounds, a sum undreamed of when the legislation was passed, and an expenditure at which even the Government might have hesitated in the days before the war. An enormous amount of money would have to be found by the London County Council in 1931, in order to effect the purchase, and if within three years of the statutory date, the council changed its mind, as councils have a way of doing, and decided to defer the purchase for another ten years, the uncertainty and inconvenience which would arise would have a disastrous influence upon the industry. The statutory right of purchase is thus a two-edged sword, but it constitutes a bargaining power which is extremely valuable if used in the Public interest.

Those who have followed the history of the London electricity supply will remember several proposals for some unification of the various interests which are involved, but they have all vanished from the scene to the benefit of nobody except the legal profession. As was their duty, the Electricity Commissioners took up the problem, and, conformably with the Acts of Parliament under which they were established, the Commissioners invited all parties concerned to propose schemes for the unified administration of the London area. Immediately after the passing of the Act of 1919, nine of the largest electric supply companies of the Metropolitan area, owning between them about two-thirds of the generating plant and mains belonging to the Companies in the County of London, came together with a view to giving practical effect, so far as they were concerned, to the intentions of the Act, namely, the cheapening and improving of the electricity supply of London by a unified policy of operation and development. Their conference resulted in the formation of a body under the name of the London Electricity Joint Committee (1920), Limited, to secure the desired co-operation between the constituent companies. The Joint Committee naturally also could speak with authority in negotiations affecting the companies' interests, and thus took its place along with the London County Council, and the Conference of Local Authorities, as one of the three great bodies whose views the Electricity Commissioners desired to harmonise.

In March, 1920, representatives of the three parties met together with the object of drawing up, if possible, a scheme which all could support at the inquiry which the Commissioners would duly hold. The outcome of the meeting was the formation of a Joint Engineers Committee, on which Sir Alexander Kennedy and Mr. Gerald Partridge should represent the companies, Mr. J. H. Rider, the London County Council, and Mr. C. H. Wordingham (afterwards Mr. Tapper and Mr. Robinson), the Local Authorities. The duties of this committee were to deal with the engineering aspects of the unification problem apart from the financial and political questions which are involved in its complete solution. Continuous work on the scheme proceeded for nearly twelve months, and the labours of the committee resulted in the presentation of a comprehensive technical report agreed to by all parties, at the London and Home Counties Electricity District Inquiry held in June, 1921. This report has since been referred to in further negotiations between the parties as "the technical scheme." The types of current and voltage to be perpetuated, and those to be eliminated, the stations to be extended and the small plants to be shut down, so as to give the most economical supply to the whole area, being matters for engineers to decide, had been decided on engineering principles and consequently all parties had come to the same conclusions. The fact that so strong a committee representing such various interests could present an agreed report raised hopes that equal agreement might be reached upon the financial and political questions which had to be faced. This, however, proved impossible, and as the inquiry proceeded it became clear that on three points at least there was a fundamental difference of opinion between the companies and local authorities. The local authorities were not prepared to surrender their generating stations to the absolute control of a Joint Electricity Authority, or Joint Board, although the companies accepted this condition. The local authorities, moreover, were not prepared to allow the companies such representation on the proposed Joint Electricity Authority, as the companies considered indispensable, and finally the companies insisted upon the principle, rejected by the local authorities, that those who found the money should have financial control.

Various efforts were made to devise some arrangement which would be acceptable to the parties concerned, but no agreement could be arrived at. The local authorities were obdurate, but the London County Council, with a better appreciation of the practical aspects of the question continued the discussion with the companies and finally a certain basis of agreement seemed possible. The lines upon which the discussion was proceeding were that the companies, in return for a prolongation of their tenure, should agree to a sliding scale of prices, under which the amount of the dividends payable to shareholders should only be increased simultaneously with a reduction in the prices charged for electricity. This is, of course, similar to the arrangements which control the dividends payable by the gas companies, and give a direct inducement to economy of working and to the lowering of prices. While these discussions were going on the Electricity Commissioners published their provisional decisions as to the constitution and powers of the London and Home Counties Joint Electricity Authority, as determined by them after hearing the representations of all parties at the official inquiry. These decisions not only set aside the agreed technical scheme which we have mentioned, but were acceptable to nobody, and, indeed, aroused active opposition from all quarters.

The first practical suggestion towards a solution of the problem presented by the incompatible views and the conflicting interests of the London undertakings was made by Mr. Fladgate, the chairman of the committee representing the London companies. Mr. Fladgate's proposal was that there should be two Joint Electricity Authorities, or Joint Boards, in the area, one representing the local authorities and the other the company undertakings. Such a scheme would not prevent the combination of the two authorities at some future time, and meanwhile it would constitute a move towards the unification which was so urgently desired. The suggestion was first made during the inquiry held in May, 1922, into the South-Eastern Railway Company's proposal to build a large generating station for their own use, and it was brought up again by Mr. Fladgate in July of that year when Sir John Snell invited representatives of the London County Council, the local authorities and the companies to meet him to discuss the draft order of the Commissioners. At this meeting the companies expressed the opinion that it would be in the interests of all parties for the company generating undertakings to be brought under one control, and stated their willingness to support a scheme for the combination of the companies to carry this into effect, provided that an extension of tenure of forty years was granted to them. As the Act of 1919 hardly contemplated such an arrangement, the companies proposed to promote a Bill in Parliament to obtain the necessary powers.

At the same meeting the local authorities suggested that they also would like powers to combine and establish a Joint Board amongst themselves to reorganise and co-ordinate their undertakings. It was thought that with the companies combining on one hand, and the local authorities combining on the other, there would be no difficulty in bringing about a voluntary co-operation between the two parties as complete as was already assured in the more limited but equally important field of technical matters. Events thus appeared to be shaping towards the creation of two joint boards, working harmoniously together, but each on its own lines and entirely responsible for its own finances. The companies would have been satisfied with this solution, which also met the views of the local authorities, although the latter did not feel the same objections as the companies to the further creation

of a Joint Electricity Authority as a co-ordinating body. The Commissioners, however, felt that the existence of such a body was not only necessary under the Act, but was also required in order to take over the purchasing rights for the company undertakings, the London County Council being willing to transfer these rights if they were satisfied as to the constitution and powers of the Joint Electricity Authority.

At the request of Sir John Snell the draft proposals of the Local Authorities and the companies were submitted to the Commissioners in writing, and the Commissioners subsequently indicated their intention of drawing up a scheme, the essence of which was the formation of a Joint Electricity Authority for London, consisting of 24 members, with an independent chairman. The London County Council would be represented by five members, the railways by two, the North Metropolitan Power Company by one, and the Local authorities and companies by eight each. This authority was to delegate its powers to two committees, one consisting of the eight local authority members and the other of the eight company members. Each of these committees was to be practically autonomous, and would have complete and entire control both technically and financially of the municipal and company undertakings, respectively. The Joint Electricity Authority was to have certain general powers, but would have practically delegated the whole of its powers to two independent committees. At an informal conference between the various parties, both the companies and the local authorities agreed that the scheme offered the basis of a workable solution, and the London County Council were willing to agree to an extension of the companies' tenure until 1971, provided that a Joint Electricity Authority was formed to take over the purchase rights and that a satisfactory scale of prices was arranged. The Commissioners thereupon undertook to prepare a draft Order for London, embodying the scheme as agreed upon.

It would appear that the negotiators representing all three of the parties concerned had certain doubts as to whether they would be able to approve the details of a scheme to the outlines of which they had assented. Hence within a few days of the discussion with the Commissioners, a meeting took place between the representatives of the local authorities, the companies and the County Council respectively, and it was agreed as essential that the promised draft Order must contain absolute safeguards to prevent either committee being responsible for the commitments or deficiencies of the other. Other points held to be essential were that methods should be provided for raising money by either committee, or by the Joint Electricity Authority, and also that the latter authority should be prohibited from either erecting or operating a generating station, or competing with either of the committees in the matter of the supply of electricity. If there was going to be trouble it was clearly going to arise on the matter of finance, for the companies had over 20,000,000*l.* of their shareholders' money at stake, the local authorities had a proportionate amount of indebtedness guaranteed by their ratepayers, and neither party overmuch trusted the financial ability of the other, or felt itself able to submit to external control in respect of such vast liabilities.

So uncertain were the companies as to the outcome of the proposals of the Commissioners, that they decided, with the full knowledge of the Commissioners, to proceed with the Parliamentary Bill which has been referred to, hoping thereby to do something towards the cheapening of electricity by unifying the generation, at least in their own areas. The Bill, which was deposited last December, made provision for the constitution of the "Committee Company" as an authorised undertaker with power to acquire or work generating stations and transmission lines. It would be compelled to supply the former owners of any station with power at a price not greater than the cost at which the former owners could have generated it themselves. The company would pay no dividends, but would apply any balance of revenue to a reduction in price of power to the constituent companies. The purchase rights under which the London County Council can acquire the undertakings of the constituent companies in 1931, should be deferred until 1971, the companies meanwhile setting aside out of revenue a sinking fund to enable them to return their capital to their shareholders at the expiry of their extended life. This would avoid the necessity for the County Council, or in other words, the Public of London, to find many millions of money for the exercise of their rights of purchase, and the undertakings would be transferred to the County Council in 1971 free of cost, except in respect of new plant purchased within a short time of that date. The companies for the period of their extended life would also be subject to a sliding scale of dividends, increasing with the reduction in the price of electricity to the consumers, so that not only the actual users of electricity, but also the London ratepayers as a whole would benefit.

This Bill, of course, had no chance of passing, but it had the effect of consolidating the position by stating clearly and unambiguously the opinions of the most experienced men engaged in the work of supplying London with electricity, as to the most practicable lines on which unification could be brought about. Meanwhile the Commissioners were at work on their draft Order, a confidential draft of which was submitted to the companies on January 20 this year. The companies at once pointed out that under the draft Order the two committees, far from being autonomous, would be practically under the complete control of the Joint Electricity Authority, as without the sanction of the latter they could neither borrow not spend any sum over 5,000*l.* Any deficits incurred by one committee would largely have to be borne by the other, the Joint Electricity Authority could apparently build and operate stations itself, in competition with both the companies and the local authorities, and in general the scheme appeared radically unsound. Moreover, it was exceedingly doubtful whether the compulsory appointment of the two committees was good in law, and if it was legal the Joint Electricity Authority might revoke the powers of the committees at any time. On January 31 a meeting of the parties to discuss the draft Order was called by Sir John Snell. With regard to the question of legality, Sir John stated that the opinion of the Law Officers of the Crown had been taken and this confirmed counsel's opinion that the proposed scheme was legal. The companies dissented, and at the inquiry opened in March, they notified the Commissioners that they intended to test the matter in the courts. The Court of Appeal decided, as has happened before, that the Law Officers' opinion was wrong, and that the scheme was *ultra vires*, and it therefore vanished from the scene, still-born on July 27 last, lamented by nobody.

What the final outcome of the position is to be, it is at present hard to say, but a solution has to be found, and events are moving in the direction of one. The London County Council, whose attitude throughout has been a thoroughly reasonable one, determined by a desire to secure unification and cheapening of electricity supply along any lines which would promise success, without regard to political considerations, has continued its negotiations with the companies' committee. The bargaining strength of the council lies of course in its purchasing rights, and it has made it abundantly clear that it is not going to surrender these rights or transfer them to any other body, without adequate assurance that the electricity consumers shall be safeguarded against the unrestrained actions of a monopolistic association of companies. The Special Committee of the London County Council on Electricity Supply has recommended the council to agree to the extension of the life of the companies until 1971 on conditions to which little exception can be taken, and to endeavour to get the draft scheme of the Commissioners modified in many important respects.

The London County Council scheme provides for a Joint Electricity Authority for the Greater London area, on which the companies shall have very small representation in view of the autonomy which they will secure under the scheme. Provided that a satisfactory sliding scale of prices and dividends can be agreed, the London companies are to be empowered to amalgamate, and to have an extension of tenure to 1971, at which time their undertakings will be transferred to the Joint Electricity Authority. The scheme provides that all assets shall be transferred to the Joint Electricity Authority free of cost, except such as shall not have been then amortised by a sinking fund to be established by the companies. The latter will have financial and administrative independence, subject only to the control of the Joint Electricity Authority on certain specified matters. These include technical developments, which must be in accordance with the agreed scheme, including a united system of generation under the control of a "technical committee" so far as the companies and the local authorities are concerned. Other matters coming under the control of the Joint Electricity Authority are that proportion of the capital expenditure which will not entirely be written off by the sinking fund before 1971, and the maintenance of the assets which will eventually be transferred to the Joint Authority. The companies are to have a right of appeal to the Commissioners with regard to the decisions of the Joint Authority on any of the matters specified.

It will be observed that these proposals of the County Council go very far to meet the obvious objections of the Commissioners' scheme. They appear to safeguard the consumers in the companies, areas by the plan of making dividends dependent upon cheapness of supply, and they provide for the whole of the companies' undertakings being transferred to public ownership and control in 1971, if it is then considered desirable. The ratepayers are relieved from the enormous increase of municipal debt which would be unavoidable were the council to exercise their present purchasing powers in 1931, and the council are not saddled with the task of operating a vast and highly complex technical and commercial enterprise. The undertakings of the local authorities do not come in under the scheme, but they would no doubt soon bring about an amalgamation of interests among themselves, under the ægis of the Joint Electricity Authority. We should thus have as nearly unified system of electricity supply in London as it appears possible to bring about under present circumstances, and one which seems to possess a considerably greater likelihood of working harmoniously and efficiently than any more ambitious attempt at unification could possess.

NEW JETTY AND EQUIPMENT, FRESH WHARF, LONDON BRIDGE.

Amongst the several riverside enterprises which have taken place since the war, the construction of the New Jetty at Fresh Wharf by Messrs. John Knill and Co., is by virtue of its position close to London Bridge, of some special interest. The design and construction of this jetty presented several exceptional features. The jetty is immediately over the twin tunnels of the City and South London Tube Railway and over the presumed foundations of one of the piers of old London Bridge. The building on the River front of Adelaide House, the prominent new structure at the north end of the bridge, necessitated a portion of Messrs. Knill and Co.'s quay accommodation being advanced into the river. Design in reinforced concrete was considered, but, as the time which could be given to the work of construction was limited to a period of six months, it was decided to carry out the major portion of the work in Oregon and blue gum timber.

The jetty has a frontage of 134 ft., with diamond ends to facilitate barges warping round, and the main deck is 18 ft. 6 in. wide before the diamond ends commence. The centre or main portion of the jetty is tied back to the concrete retaining wall of the foundations of Adelaide House by steel girders decked over to give a total deck area of approximately 2,800 sq. ft. (see general plan, Fig. 2). The original design of these connecting girders as shown on plan was subsequently modified at the request of the engineers for the construction of Adelaide House foundations so as to comprise four main girders suitably strengthened for trimmers to carry the land ends of the other four girders. Two-thirds of the jetty is in front of Adelaide House—an arrangement which was come to by agreement between Messrs. John Knill and Co., and the proprietors of that building, one entrance and exit to the new jetty being through the latter property.

It was at first intended to have a barge berth behind the jetty with a steel girder bridge as an

JETTY AT FRESH WHARF, LONDON BRIDGE.

CONSTRUCTED TO THE DESIGNS OF MESSRS. CAREY AND LATHAM, ENGINEERS, WESTMINSTER.

Fig. 1. ELEVATION OF RIVER FACE OF JETTY.

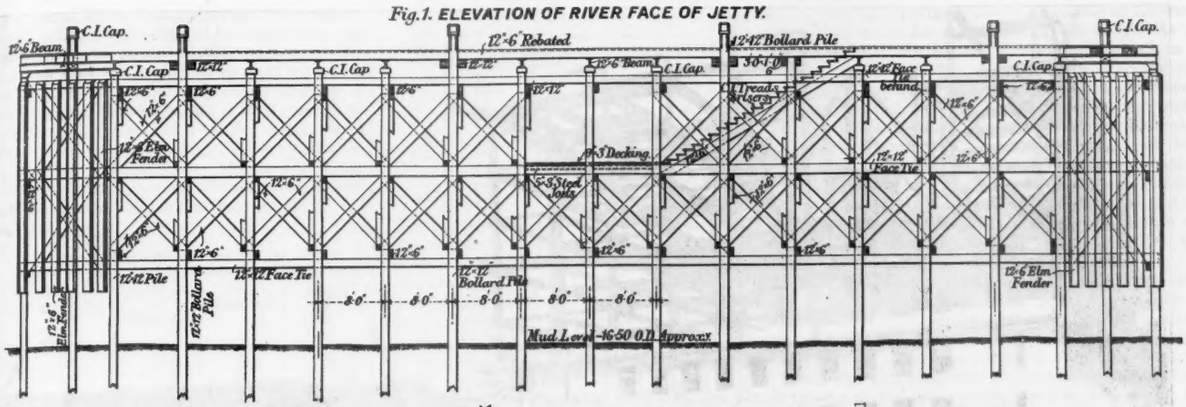


Fig. 2. PLAN.

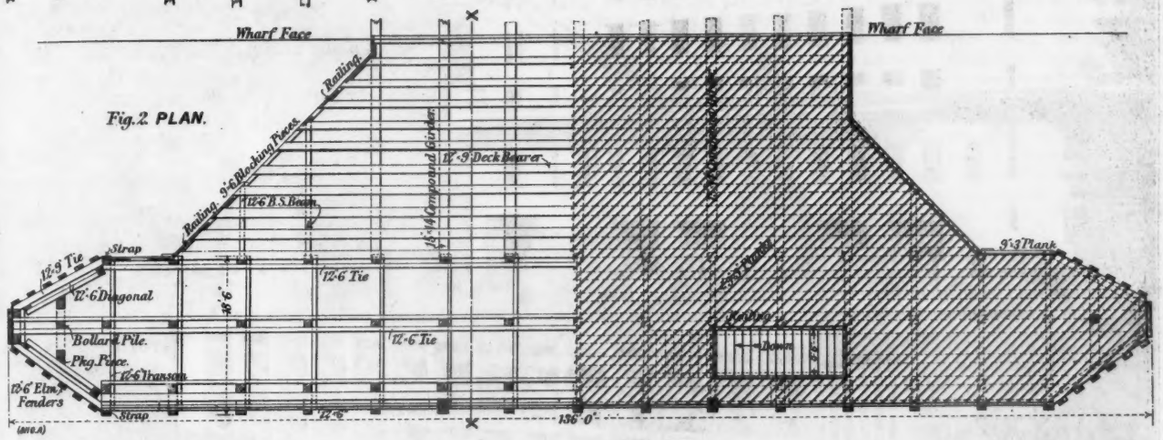


Fig. 3 CROSS SECTION THRO' JETTY AT X-X.

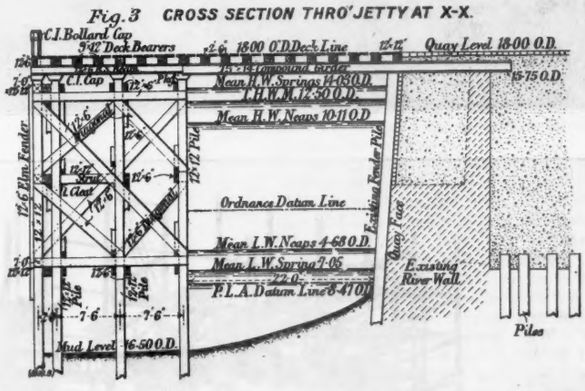
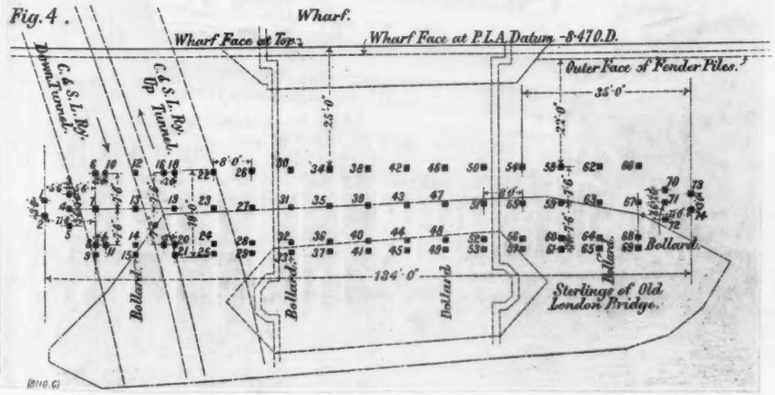


Fig. 4.



approach, but, owing to the fact that the Port of London Authority would only allow the outside face of the jetty to extend 42 ft. from the face of the old river embankment and insisted on a free waterway behind the jetty head at this congested point of the Thames, this idea had to be abandoned, as it was felt that a jetty only 18 ft. 6 in. wide with no lateral support would probably fail under the impact of ships coming alongside at high tide. The heavy steel girders referred to above which were introduced into the design and anchored into the foundations of Adelaide House have a span of 38 ft., necessitated by the fact that no load could be permitted to fall on the wall forming the old embankment (see Fig. 3).

The main structure of the jetty (*i.e.*, piles, bracings, transoms, decking, deck bearers, &c.) is in timber, but the deck is carried over the pile heads by means of cast-iron caps and steel beams—this design having been selected owing to steel and cast-iron not being affected by decay to the same extent as timber, and as the steel beams formed a convenient and rigid frame for tying up to the connecting steel girders referred to above.

The front piles were of blue gum and the remainder of Oregon pine. All other timber members were of pitch pine. The blue gum piles were strengthened by driving a second Oregon pile immediately in rear as shown in the section (Fig. 3). The 9-in. by 3-in. decking was laid at an angle of 45 deg. to the centre line of the jetty to assist in stiffening the structure. This decking is laid on timber deck bearers, which in turn are bolted to the steel beams. The deck bearers are of 12-in. by 9-in. section, but, as the construction of Adelaide House foundations had reached a level of 15·75 O.D. before the design of the jetty was put in hand, these bearers had to be laid flat, *i.e.*, with their depth only 9 in. to allow of a standard deck level of 18·0 O.D. being maintained. They had to be spaced at intervals of 2 ft. 6 in. centres in order to carry the specified load.

JETTY AT FRESH WHARF, LONDON BRIDGE.

CONSTRUCTED TO THE DESIGNS OF MESSRS. CAREY AND LATHAM, ENGINEERS, WESTMINSTER.

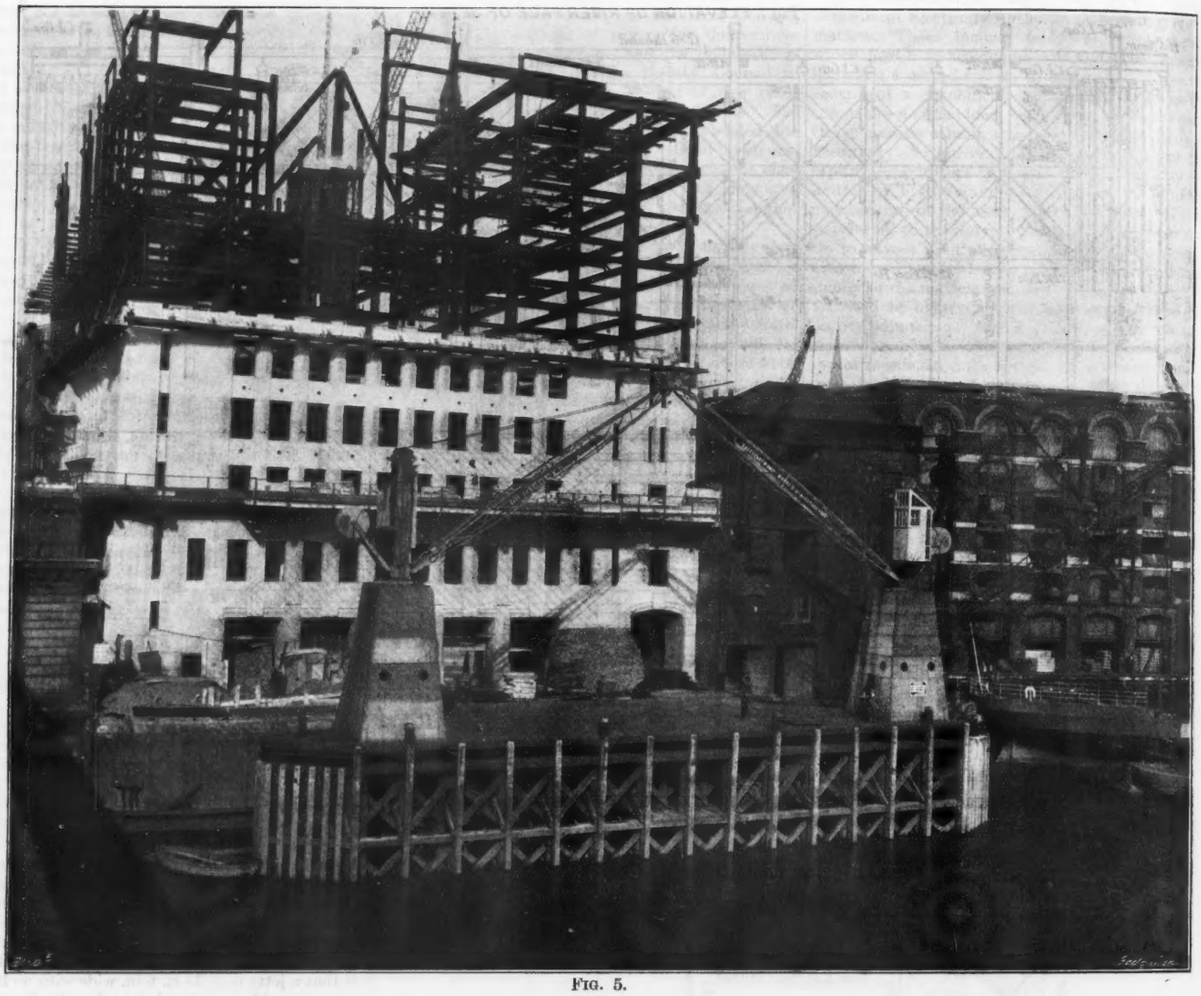


Fig. 5.

Unless the reason for this arrangement of deck bearers is appreciated it would otherwise constitute a bad feature of design. The deck itself is designed to carry a load of 2 cwt. per square foot—apart from the weights of the cranes, for which special provision was made.

The contractor was given occupation of the site on March 31, 1923, and, owing to the character of the trade carried on at Fresh Wharf, it was necessary that the jetty should be entirely finished in the autumn of the same year. The work was actually completed about the middle of October, 1923, and shipping occupied the berth in the same month. Two test piles were driven before the work was commenced at points considered to be the most vital, as some difficulty was anticipated both in respect to the doubtful holding nature of the ground and in view of possible obstructions occurring due to the existence of the old bridge foundations.

At a penetration of approximately 29 ft. below the river bed a final set of $\frac{1}{10}$ in. per blow was arrived at, for the up-stream test pile, whereas the down-stream (or No. 2) test pile gave a set of $\frac{1}{4}$ in. with a penetration of approximately 25·5 ft. These sets were obtained with a drop hammer weighing $1\frac{1}{2}$ tons falling 5 ft., and were regarded as satisfactory for the general purposes of construction, but insufficient for the crane foundations.

The cranes being of the pillar type as illustrated in the accompanying view, Fig. 5, were designed for four-point supports. In the case of the up-stream crane it was felt that the set likely to be obtained at the shallow depth to which it was permissible to

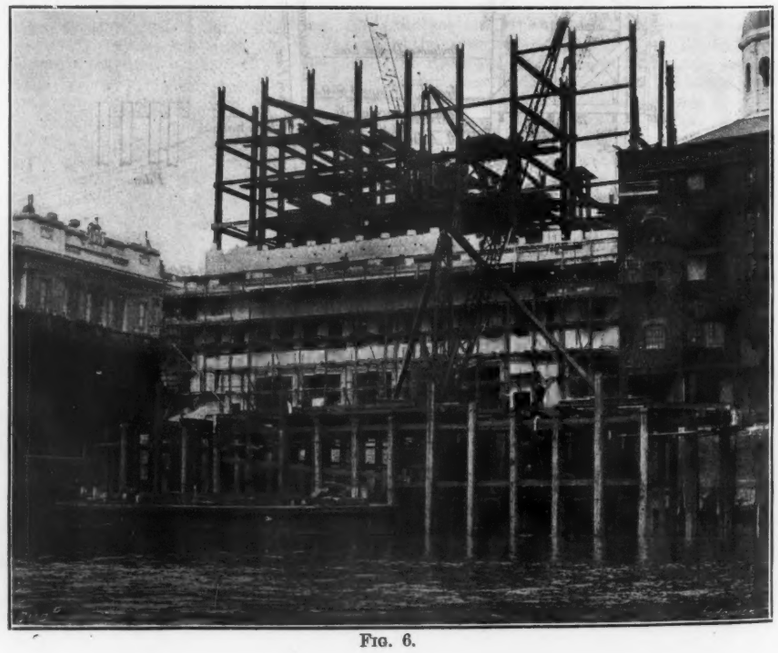


Fig. 6.

drive the four supporting piles would be unsatisfactory and these piles were therefore duplicated. The depth to which these piles could be driven was fixed at — 37 O.D. as a maximum in view of the fact that the crowns of the tunnels of the City and South London Railway passed underneath at a level of — 47 O.D.

In the case of the down-stream crane the necessary additional support was obtained by lengthening the piles and driving to greater depths and more severe sets. In view of the geological interest attaching to this city area with its sharply changing levels of London clay and Thames ballast it is of interest to examine the piling plan and a tabular statement of results obtained in pile driving. These records are shown as to the position of the piles in Fig. 4, on page 703, and by the recorded sets and penetrations of half the number of piles driven, set out in the subjoined table.

Record of Pile Driving (see Fig. 4).

Pile No. on Plan.	Level of River Bed, O.D.	Penetration in River Bed.	Final Set.	Length of Pile Pitched.
		ft. in.	in.	ft. in.
1	−16·53	19 6	1/16	54 6
3	−16·79	19 10	1/16	55 6
5	−17·27	19 4	1/16	56 8
7	−15·77	20 10½	1/16	54 6
9	−17·34	19 0	1/16	55 0
11	−17·34	12 1	1/16	54 6
13	−16·76	19 9	1/16	54 6
15	−17·21	19 8	1/16	61 6
17	−16·74	19 7	1/16	54 6
19	−15·88	20 8	1/16	56 8
21	−17·28	19 5	1/16	55 4
23	−17·06	19 10	1/16	57 0
25	−18·34	18 5	1/16	56 0
27	−18·57	17 8	1/16	56 1
29	−18·58	18 3	1/16	55 6
31	−18·28	21 9	1/16	59 3
33	−17·80	22 6	1/16	62 4
35	−17·74	20 0	1/16	55 0
37	−18·78	20 1	1/16	56 0
39	−16·53	20 2	1/16	55 0
41	−16·27	20 2½	1/16	55 6
43	−17·02	19 10½	1/16	55 0
45	−17·24	20 10	1/16	55 6
47	−16·23	22 0	1/16	56 6
49	−16·72	21 9	1/16	60 9
51	−15·48	22 9	1/16	57 0
53	−15·72	22 5	1/16	56 6
55	−15·25	20 3	1/16	54 6
57	−15·48	23 6	1/16	56 6
59	−15·75	21 6	1/16	55 6
61	−16·06	22 8	1/16	56 6
63	−14·97	23 6	1/16	56 6
65	−15·22	23 4	1/16	61 0
67	−14·31	24 4	1/16	58 0
69	−15·78	22 5	1/16	56 0
71	−15·34	22 6½	1/16	60 0
73	−14·86	24 2	1/16	57 6

NOTE.—The piles were driven with a McKiernan-Terry steam hammer (double-acting) No. 9; weight of piston, 1,250 lb.; cylinder diameter, 15 in.; cylinder stroke, 12 in.; steam pressure, 80 lb.; approximate average number of strokes per minute, 60. Piles Nos. 6, 8, 18 and 20 are crane piles, 14 in. by 14 in.; piles Nos. 10, 11, 16, 17, 58, 60, 66 and 68 are crane piles, 12 in. by 12 in. A test with a 2½-ton drop hammer and a 4 ft. 6 in. drop was made on No. 17 pile, the shoe level at start being −30·24 O.D. and at finish −31·34 O.D. The average penetration per blow was ¼ in.

The piles were driven by a No. 9 McKiernan-Terry steam hammer, and although several calculations were made as to the safe resistance of these piles to vertical loading, especially in the case of the crane foundation piles, it was deemed desirable to refer the results in the latter cases to the British Steel Piling Company as manufacturers of the pile-driving plant who possessed valuable comparative information as to the resistance of piles driven in this manner compared with that of piles driven with the ordinary hammer. This company very courteously fully examined the results and expressed the view that the crane foundation piles as driven would withstand the following ultimate bearing loads:

	Tons.
Pile No. 6	53·5
Pile No. 8	64·4
Pile No. 10	81·5
Pile No. 11	82·1
Pile No. 16	58·3
Pile No. 17	66·4
Pile No. 18	58·3
Pile No. 20	66·4
Pile No. 58	83·2
Pile No. 60	83·2
Pile No. 66	80·0
Pile No. 68	74·6

The photograph, Fig. 6, on page 704, shows the jetty just after pile driving had been completed and was taken on June 20, 1923. The level of the river bed averaged — 16·5 O.D. and an average penetration of 21 ft. was obtained at the points of the pile shoes. The average penetration is lowered by the fact that in the vicinity of the "tube" tunnels no pile was permitted to approach them within a radius of 10 ft.

The two hydraulic cranes shown in the photograph, Fig. 5, were manufactured and supplied by Messrs. The East Ferry-road Engineering Works Company, Limited, to the specification of Messrs. Dudgeon and Gray, of 89, Aldgate, E.C. The up-stream crane has the following speeds:—

Lifting with 25-cwt. load	250 ft. per minute.
Slewing with 25-cwt. load	1 revolution in 40 seconds
Luffing with 25-cwt. load	From maximum to minimum rake in 40 secs.

The water consumption per cycle does not exceed 43·4 gallons.

The down-stream crane is provided with two rams and has the following speeds:—

Lifting with 25-cwt. load	250 ft. per minute.
Lifting with 45-cwt. load	200 ft. per minute.
Slewing	1 revolution in 40 secs.
Luffing	From maximum to minimum rake in 40 secs.

The water consumption per cycle with this crane does not exceed 44·9 gallons with the 25 cwt. load and 57·7 gallons with the 45-cwt. load. Both cranes are designed for a working pressure of 700 lb. per square inch.

A specially designed three-cylinder hydraulic turnover type of capstan has been supplied by the same company, and is fixed at the eastern diamond end to assist in warping barges. The capstan itself is capable of exerting a direct pull of 1 ton and has a hauling speed of 100 ft. per minute. The jetty is, of course, provided with the usual fendering, stanchions and ladders, and has a half-tide landing stage with removable hatchways.

The contract work for the jetty was admirably carried out under considerable difficulties by Messrs. Robert McAlpine and Sons, of 50, Pall Mall, and the fullest information and assistance was kindly given by Messrs. Mott, Hay and Anderson, of 9, Iddesleigh House, Caxton-street, Westminster, the consulting engineers to the City and South London Railway. The steelwork for the jetty was supplied by Messrs. Dawnay and Sons, Limited, of Steelworks-road, Battersea, S.W. Messrs. Carey and Latham, M.M.Inst.C.E., of 36, Victoria-street, Westminster, S.W. 1, being appointed consulting engineers for the design and supervision of the work. The jetty as finished is shown in the photograph, Fig. 5, on page 704.

THE COMMERCIAL MOTOR TRANSPORT EXHIBITION AT OLYMPIA.

(*Concluded from page* 696.)

IN transport systems where very rough roads have to be encountered or the gradients are many and steep, the application of the power provided by the engine to all four wheels has great advantages. A vehicle, so fitted, may be run into a cross trench quite three feet depth, and from that position may be driven out successfully and easily. In the European War many transport wagons having this drive, were put to valuable service under most exceptional conditions. The wagons of this type used in the war were either American in origin or constructed in this country by the Ministry of Munitions. A British company has now been formed and an extensive factory has been equipped at Slough for their production. This concern, the Four-Wheel Drive Company, Limited, specialises in the manufacture of one standard chassis having a carrying capacity of 3 tons, excluding an allowance of half a ton for the weight of the body. At the Exhibition the chassis was shown, as well as its application to a lorry, a fire engine and a three-way tipping wagon. Actually the last-mentioned machine has associated with it, a tipping trailer, and both are equipped with Westinghouse air brakes, which ensures an immediate stoppage of both wagon and trailer should they become detached. As the system of driving is of considerable interest and importance, illustrations of the chassis and the construction of the transmission components are shown in Figs. 49 to 59, on pages 706 and 707.

The frame of the chassis is made up from heat-treated nickel chrome steel pressed into channel form and with suitable sections of similar material riveted to the flanges as cross-ties. Two well-supported stretchers, extended between two of the ties and also connected to the side members of the frame at the mid-section, serve as bearers for the engine and gear-box. The rear end of the frame is mounted on a platform spring, the side members of which are fixed to the top of the axle case very close to the wheels to secure stability, while the forward ends of these rear springs are effectively supported by brackets on the outside of the frame. A tie-bolt of chrome vanadium steel extending across the width of the chassis, prevents the distortion of the frame members, which otherwise might be caused by the spring suspension. At the front end semi-elliptic springs connect the frame to the front axle.

A four-cylinder engine, with the cylinders cast in pairs and with the valves on each side of the T-shaped heads, gives a rated horse-power of 36·1. The bore is 4⅜ in. and the stroke 5½ in. The cylinders are offset ⅜ in. and the pistons are made long, actually 6¼ in., to ensure long life in service. Each piston has three rings near the top and four oil grooves in the skirt. Ample cooling by jacket water round the valve seats is a feature of the design, and the stems and tappet systems are lubricated by a mist of oil enclosed within spring-retained covers. The camshaft is supported in three bronze bearings, and is driven by helical gears from the front end of the crankshaft. Lubrication is effected by the combined force feed and splash system. In the design, every care has been taken to cut down the time necessary for adjustments and replacements. The carburettor is of the plain tube pattern with double Venturi tubes to which all the air enters by a single opening, after being heated. A control is fitted which can be used to restrict the incoming air to facilitate starting. A governor prevents the attainment of speed of running of the engine in excess of 1,350 r.p.m. It is driven from the back end of the exhaust camshaft. The clutch is of the Hele-Shaw type with 23 copper and steel discs running in oil. The characteristics of this design are very suitable for a motor vehicle, as the sudden grip between the plates is prevented through the presence of an oil film, ensuring gradual engagement, eliminating shock to the engine and transmission system and reducing tyre maintenance costs. The drive is taken through a fabric type of universal joint to the gear-box, which gives three speeds ahead and one reverse. The design of the standard equipment is shown in Fig. 53, from which it will be seen that the gear wheels are always in mesh, but are brought into operation by the movement of jaw or dog clutches, each with six heavy projecting teeth. For some services a greater variation in speed is desired, and for that purpose the makers have designed, what they term, a "booster" gear. This simple device for altering the gear ratio is shown in section in Fig. 52. It is simply a combination of gear wheels to give a speed reduction or through which a direct drive can be taken. Where it is installed intermediate speeds between those of the standard gear may be obtained and thus six speeds ahead and two for reverse running are available. From the rear end of the gear shaft

3-TON F.W.D. MOTOR LORRY.

CONSTRUCTED BY THE FOUR-WHEEL DRIVE COMPANY, LIMITED, ENGINEERS, SLOUGH.

Fig. 49

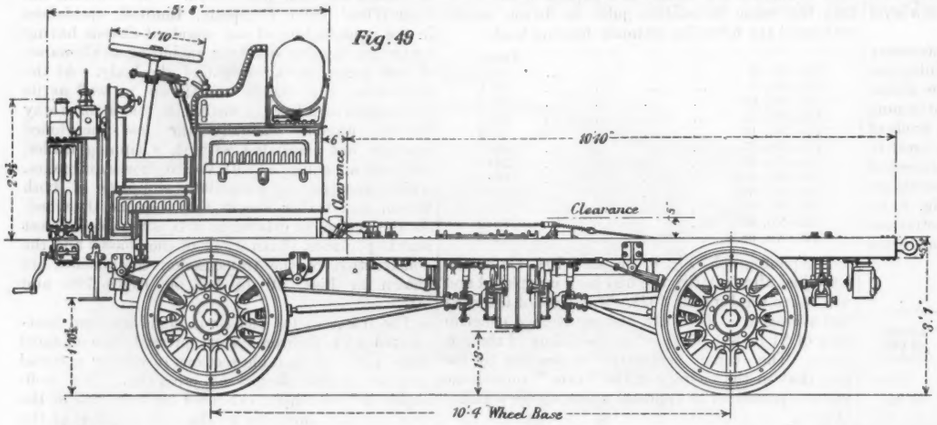


Fig. 50.

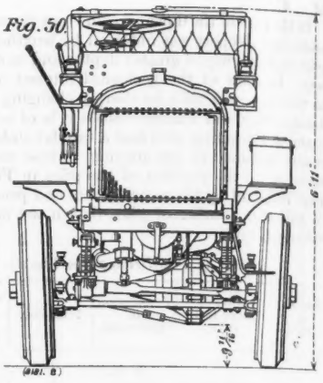


Fig. 51.

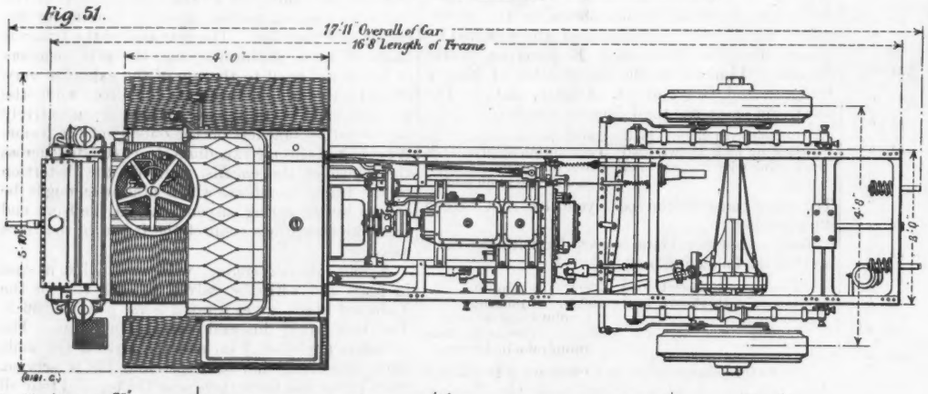


Fig. 52.

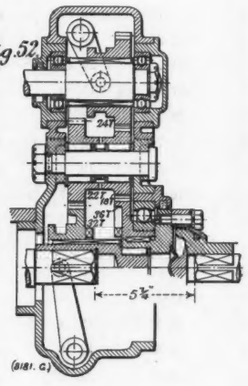


Fig. 53.

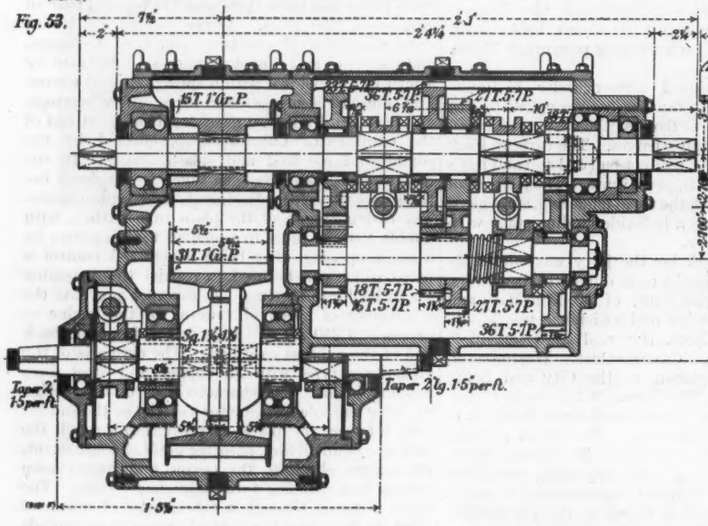
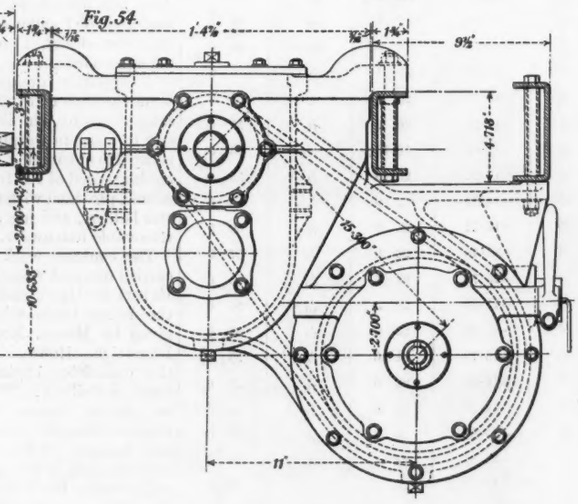


Fig. 54.

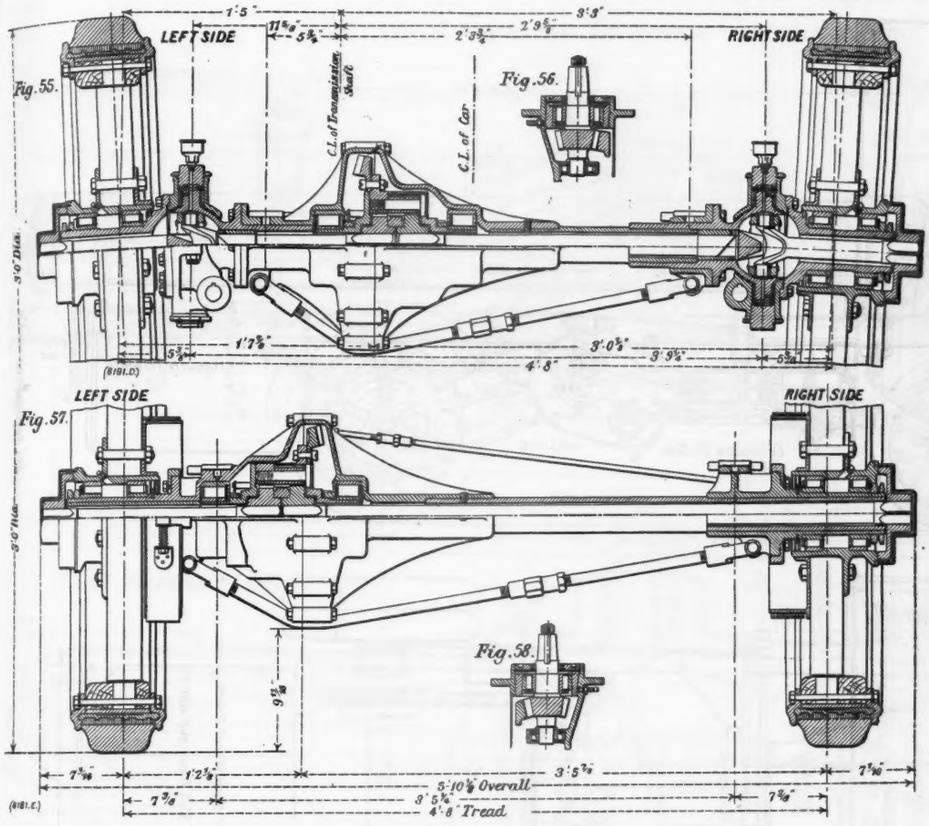


a silent chain drives a differential from which the power is transmitted to the front and rear axles. This central differential is necessary to compensate for the momentary difference in the speeds of turning of the front and back axles when rounding corners or travelling over uneven ground. When traction is only obtainable from one end of the system, loss of power is prevented by means of a lock operated through a hand lever. This consists of a jaw clutch which is movable along the axle shaft to engage with jaws on the case of the differential. The power losses due to one pair of the wheels turning but giving no tractive effort is thus avoided. The front and rear axles have many points in common. Their construction is indicated in Figs. 55 to 58. Shafts extend from the centre differential to each to give the necessary rotation through a bevel pinion and wheel. Differentials are fitted to each axle to give the correct relationship of travel in turning. By the combined use of the three differential systems all the necessary wheel speed variations may be obtained. The front axle housing is of the fully-floating type, but is made at the wheel ends in the form of a ball, from a chrome vanadium steel drop-forging. Heavy pivots project from the ball and are accommodated in a spherical socket divided into an upper and lower half. All the load is carried through the pivots and their bushings. The axle shaft passing within this ball and socket joint is provided with a universal joint to permit the freedom in turning which is requisite. The foot brake is mounted on the cross-member behind the gear-box. It is of the external contracting type and is accessible for adjustment. The retarding action is applied through the driving shafts to all four wheels, but there is provided, in addition, a powerful brake, again of the external contracting type, on each rear wheel, this being put into action by means of a hand lever.

This system of propelling a motor vehicle has been applied extensively to operations on light railways in this country and abroad. One of the machines on show at Olympia had on each of its four wheels a different type of tyre such as is used in the various services to which the four-wheel drive system has been applied. These tyres are, respectively, a pneumatic, a solid rubber, a steel railway tyre and that interesting combination for both road and rail service, the Motorailer, devised by General Holden, which was described recently in ENGINEERING (see page 472 *ante*).

3-TON F.W.D. MOTOR LORRY.

CONSTRUCTED BY THE FOUR-WHEEL DRIVE COMPANY, LIMITED, ENGINEERS, SLOUGH.



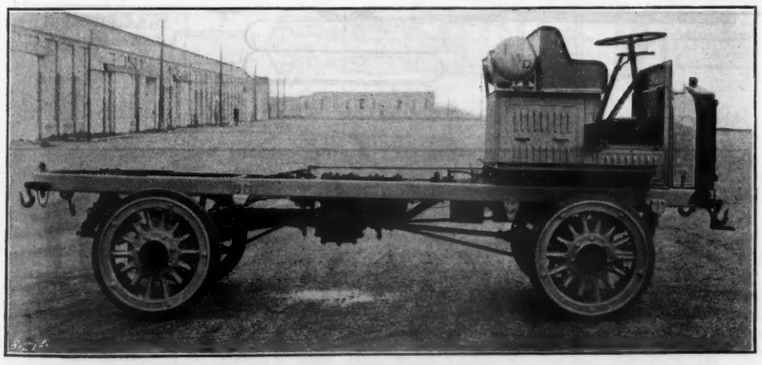


FIG. 59.

Messrs. Clayton Wagons, Limited, of Lincoln, who are associated with the well-known firm of Clayton and Shuttleworth, of the same city, who have been makers of steam road wagons for more than a dozen years, exhibited a steam-wagon of the undertype design, the construction of which will be understood from Figs. 60 to 62, page 708. The makers, who also build overtype steam wagons recommend the latter for general jobbing work and particularly over bad roads, the undertype pattern being more generally suitable for rapid transport on good roads where large body space is an advantage, or for use under conditions which call for manœuvring in confined spaces. The overall dimensions of the standard Clayton 6-ton undertype wagon are given in Figs. 60 and 61, so that we need not repeat them here. The vehicle has a bunker capacity of 5 cwt. of coal and carries normally about 150 gallons of water. It will climb gradients of 1 in. 6 with full load, and under the same conditions is capable of a sustained speed of 15 m.p.h. on the level.

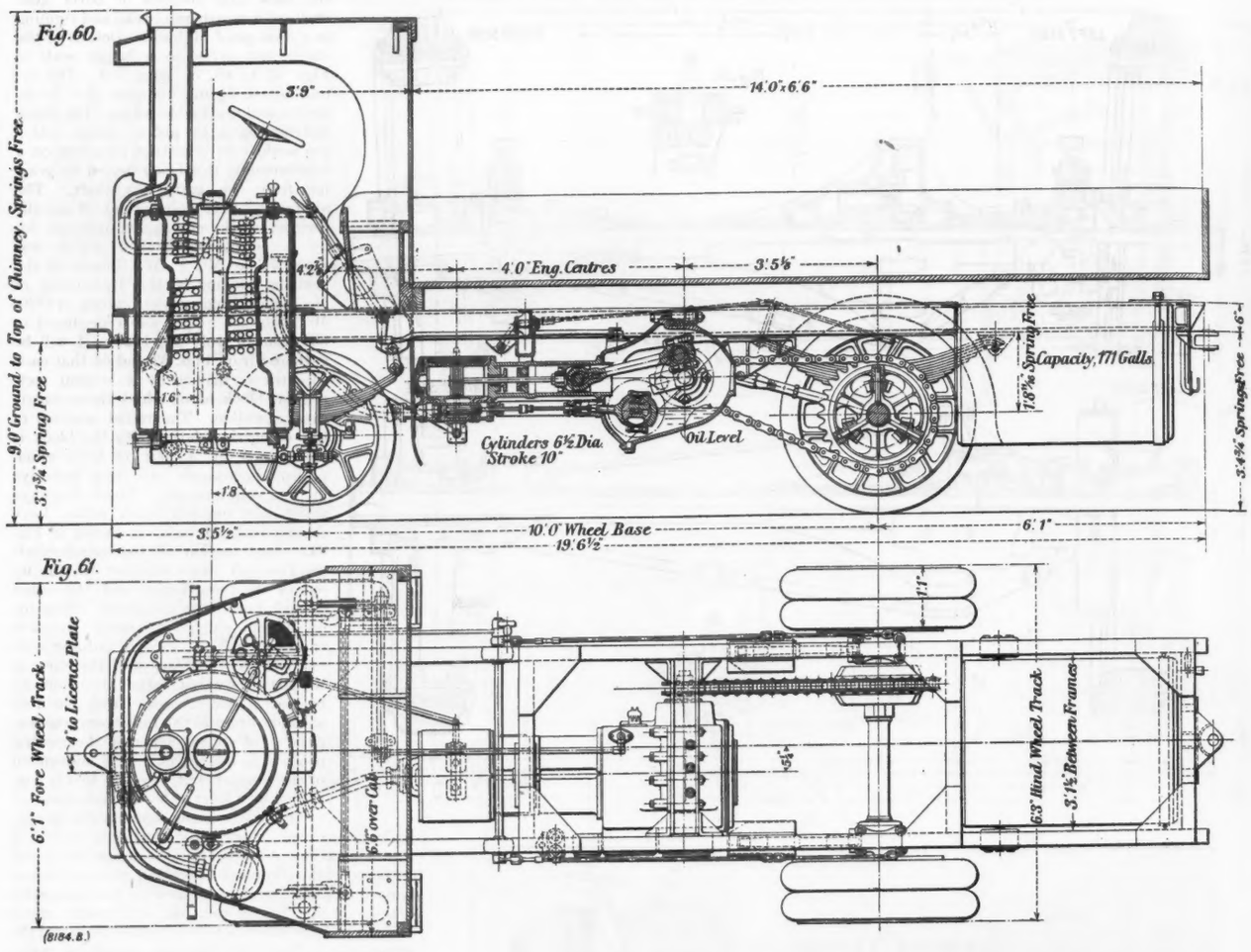
The boiler is of the vertical cross-tube type with a coil superheater, and is fired by a central shoot from the top in the usual way. The working pressure is 230 lb. per square inch, but every boiler is tested to a pressure of 400 lb. per square inch in the presence of an inspector of a boiler insurance company before leaving the works. The outer shell of the boiler is cylindrical, and the top and bottom of the fire-box are also cylindrical, but the central portion of the latter is pressed into a square section to form flat faces into which the tubes are expanded. To clean the inside of the boiler and the tubes, the whole fire-box can be removed from underneath after the bolted joints at top and bottom have been undone. The engine is of the two-cylinder high-pressure horizontal design, carried underneath the platform as shown in Figs. 60 and 61. There is a direct drive from the crank-shaft to the back axle by means of a heavy roller chain. The differential on the back axle consists of bevel gear enclosed in a cast-iron casing and running in a dust-proof oil bath. Details of the engine are given to a larger scale in Figs. 63 to 66, on page 709. The cylinders are 6½ in. diameter by 10 in. stroke, and are double-acting. The steam distribution is by piston valves, which are worked by eccentrics mounted on a countershaft, this being driven by gearing from the main crankshaft. The alteration of the point of cut-off and the reversal of the engine are provided for by a simple mechanism which was described by Mr. P. W. Robson at the summer meeting of the Institution of Mechanical Engineers at Lincoln, in 1920. Mr. Robson's paper was reproduced in our issue of July 23, 1920. It will be gathered from Figs. 63 and 64 that each eccentric is driven by a central rectangular block, along which the eccentric sheaf can slide. The radial position of the eccentric relatively to the block is determined by a pair of keys which project downwards into deep keyways in the countershaft. These keyways which are opposite each other have sharply-inclined beds, as shown in Fig. 64. Any motion of the countershaft endwise will cause one key to ride up out of the countershaft and the other to sink lower into the shaft. Thus the eccentric, which is unable to slide endways, will be moved radially with reference to the block and therefore to the shaft. By this means the cut-off can be varied continuously from the full-ahead position to the full astern position, passing, of course, through the neutral position in its travel. The movement of the countershaft to effect this is controlled by a lever at the driver's seat.

The valves being underneath the cylinders are well placed for drainage, which is a consideration. A further point of design which will be noted is the complete separation of the cylinders from the crank chamber. There are two accessible glands on the piston rod, one to prevent steam leakage and the other to prevent oil leakage, and the arrangement effectively prevents steam or water finding its way into the crank chamber and spoiling the lubrication. All bearings of the Clayton engine are accessible and adjustable, plain bush bearings not being used at all. The boiler-feed pump, illustrated in Fig. 67, is of the simple ram-type driven at a reduced speed by gearing from the crank-shaft. An ejector for feeding the boiler is provided in addition to the pump. The wagon is fitted with either steel or rubber tyres, as required, the latter being of course advisable when high road speeds are desired. The steering is of the Ackerman pattern with wheels swivelling from their centre, so that there are no overhung bearings. Each rear wheel is fitted with a powerful expanding brake, Ferodo-lined, operated by a foot pedal in the driver's cab. The engine, of course, can also be used as a brake in emergency. It should be mentioned that a feed-water heater forms part of the standard equipment of the wagon.

The Maudslay Motor Company, Limited, of Parkside, Coventry, manufacture a range of seven sizes of chasses for motor vehicles, and of these, four were exhibited, equipped with bodies for various services. The illustrations, Figs. 68 to 72, on pages 710 and 711, show some of the important details of the one which was specially designed for service in passenger carrying by char-a-banc, double deck or large single-deck 'bus. The engine is a four-cylinder unit of monobloc construction and with dimensions of 4½ in. bore and 6 in. stroke. It develops 44 h.p. at 1,000 r.p.m. A section showing the arrangement of this engine is given in Fig. 68. The detachable cylinder heads are cast in pairs. They contain the overhead camshaft, which is driven by a vertical shaft through bevel gears from

6-TON UNDERTYPE STEAM WAGON.

CONSTRUCTED BY MESSRS. CLAYTON WAGONS, LIMITED, ENGINEERS, LINCOLN.



the crankshaft. Allowance for the expansion of the vertical shaft has been made by the introduction of a coupling, specially designed for the purpose. A transverse shaft drives the water-circulating pump and magneto (see Fig. 68). Lubrication is effected on the pressure feed system for the crankshaft bearings and connecting rod big-ends, and by the splash method for the piston. A pressure release valve for the oil system is available, and the pump and filter may be taken out without disturbing the sump. As the crankshaft is supported in bearings in the upper portion of the crank chamber the oil sump is left as a detachable component, and its removal enables access to the crankshaft from below. From the engine, the drive is taken through an inverted cone ring bolted on the flywheel to a leather faced clutch, Fig. 69. A clutch stop is provided in the form of a ring with a facing of Ferodo which is supported by straps across the sub-frame. A flange connected to the moving system is pressed against this ring stop when the clutch is disengaged.

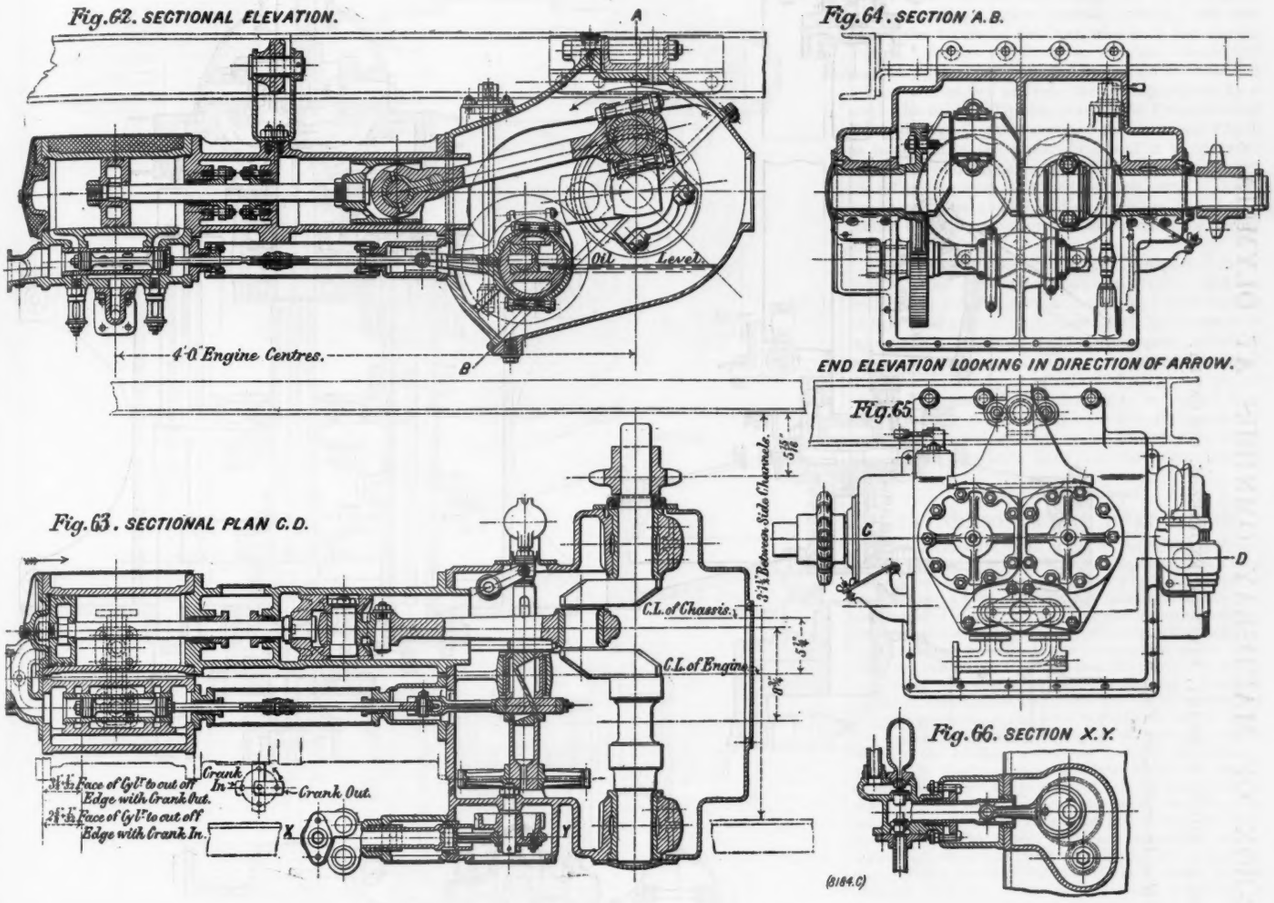
The gear-box, Fig. 70, provides for four forward speeds and a reverse, and is operated by a hand-lever with a gate quadrant. Splines are provided on the gear shaft to permit the movement of the wheels on it and so obtain engagement of the various wheel combinations in turn. It will be observed from the illustration that the shafts on the gear-box run on ball bearings and that the drive is carried through to a spherical encased type of universal joint, on the outer case of which is a pedal-controlled brake. From the universal joint the propeller shaft extends and has at its end (see Fig. 71) a pot type of joint with a sliding T-piece. For the final drive to the

Fig. 62.

axles a worm and worm-wheel combination is used, and on the worm wheel a differential with spur wheels is mounted. This mechanism is enclosed in a casing which can be withdrawn as a unit from the usual Maudslay bridge type of axle, which is forged from a solid billet. As this forging takes all the dead-weight the shafts are only subjected to driving torque. The construction at the wheel end of the back axle is illustrated in Fig. 72, which also shows one of the rear brakes, for which the drum is bolted to the spokes of the wheel. This brake is of the internal-expanding type, for which provision is made for

6-TON UNDERTYPE STEAM WAGON.

CONSTRUCTED BY MESSRS. CLAYTON WAGONS, LIMITED, ENGINEERS, LINCOLN.



hand adjustment. The steering is effected through a worm and sector gear set, and the transverse compression rod is located behind the front axle. Semi-elliptic springs placed at all the four wheels support the frame and the propulsion and transmission machinery.

Although among the pioneers of the motor vehicle industry and the producers of many successful machines, the firm of John I. Thornycroft and Co., Limited, of Basingstoke, show no signs of abating their efforts or of resting on their laurels. By careful consideration of design they have maintained their position, and their latest achievements are in no degree less remarkable than those that might be expected. Recently a Thornycroft lorry, carrying a load of 6¼ tons was subjected to a 1,000 miles trial by the Royal Automobile Club, the weight of the wagon being 4 tons 10½ cwt. The trial occupied ten days between November 8 and 19, 1923, and was run over a route through Barnet, Welwyn, Hitchin, Biggleswade, Tempsford, Eaton Socon and back. In this test an average speed of 11·9 m.p.h. was maintained and the fuel consumption found was 11·28 miles per gallon, equivalent to 123·34 ton-miles per gallon. This result places the work of British manufacturers again at the top of the records for fuel consumption in the tests of commercial vehicles, and is 20 per cent. better than the figures obtained in a similar best with a Swiss machine, whose builders held the record for a short period. Thornycrofts deserve the congratulations of all interested in the maintenance of the excellence of British manufactures on the attainment of this record. It may be recalled that a 2-ton lorry entered for a similar test two years ago, gave such exceptional results that the firm were awarded the Dewar trophy for "the most meritorious performance of the year in R.A.C. trials," but the latest test shows a great advance on the results then attained.

Illustrations of the chassis and engine of one of the Thornycroft exhibits, the J type double-decked omnibus, are given in Figs. 73 to 78, on Plate XLI. A large number of 'buses of this type are at present under construction for the Cambrian Coaching and Transport Company, Limited. This chassis has the new forward control, and the frame is made up from pressed steel of channel section, which combines strength with lightness. A single steel drop-forging of H section forms the front axle on which swivel arms of the central pivot type are mounted to ensure easy steering in spite of the weight of the vehicle. The back axle is of the overhead worm gear type, the central portion being a steel casing into which is fitted a differential worm gear carried in a housing which may be removed bodily at any time without taking the load off the road wheels. The engine, a new design, is of 50 h.p. and has four cylinders of 4¾ in. bore and 6-in. stroke. The monobloc cylinder casting is provided with two detachable heads which accommodate the inlet valves. These are of the overhead type, but the exhaust valves are the common form and located on the cylinder casting below the inlet valves. Both sets are operated from the same camshaft, as may be seen on the right-hand side of the engine in Fig. 77. The drive of the camshaft is obtained from the crankshaft through a single helical gear. Care has been taken in balancing the crankshaft in order to eliminate distortion when running at high speeds and to keep down the bearing pressures. For lubrication purposes the oil gathers in the sump and is drawn first through a layer of gauze and then through a cloth bag to strain out the small particles of carbon which might cause excessive wear in the bearings and cylinders. It may be mentioned that the cloth filter can be taken out for cleaning or renewal without loss of oil and without draining the oil off from the sump. A relief valve is fitted to maintain the oil at the correct pressure, and a dipping rod is provided for ascertaining the level. The water-circulating pump and fan are one unit driven by a V-belt from the magneto driving shaft. A clutch of the cone type is fitted. The cone is a steel pressing lined with Ferodo, which engages with the cast iron flywheel. The springs for this clutch are easily accessible for adjustment and a heavy stop is fitted to facilitate the gear changes. Between the clutch and the gear-box there is a leather disc-type universal coupling. Both the primary and the secondary shafts of the gear are run on ball bearings, and there is a ball thrust fitted behind the brake drum. The drive on top gear is direct, and there are also three indirect gear combinations available for ahead running and one for reverse. The brake on the transmission system is of the contracting type, and is operated from a pedal while one of the expanding form is fitted to each back wheel, and they are actuated by a hand lever. The equipment includes two dynamos for lighting purposes and they work in association with a battery. The 'bus body fitted to this chassis in the exhibition has been designed to meet all the requirements of the Metropolitan Police for service in London, and may therefore be recommended for other services.

The undertype steam wagon exhibited by Messrs. Richard Garrett and Sons, Limited, of Leiston, is illustrated in Fig. 79, on Plate XLI, while a tracking trailer for use in association with it is shown on

ENGINE CLUTCH AND GEAR-BOX OF MAUDSLAY OMNIBUS AT OLYMPIA.

CONSTRUCTED BY THE MAUDSLAY MOTOR COMPANY, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 705.)

Fig. 68.

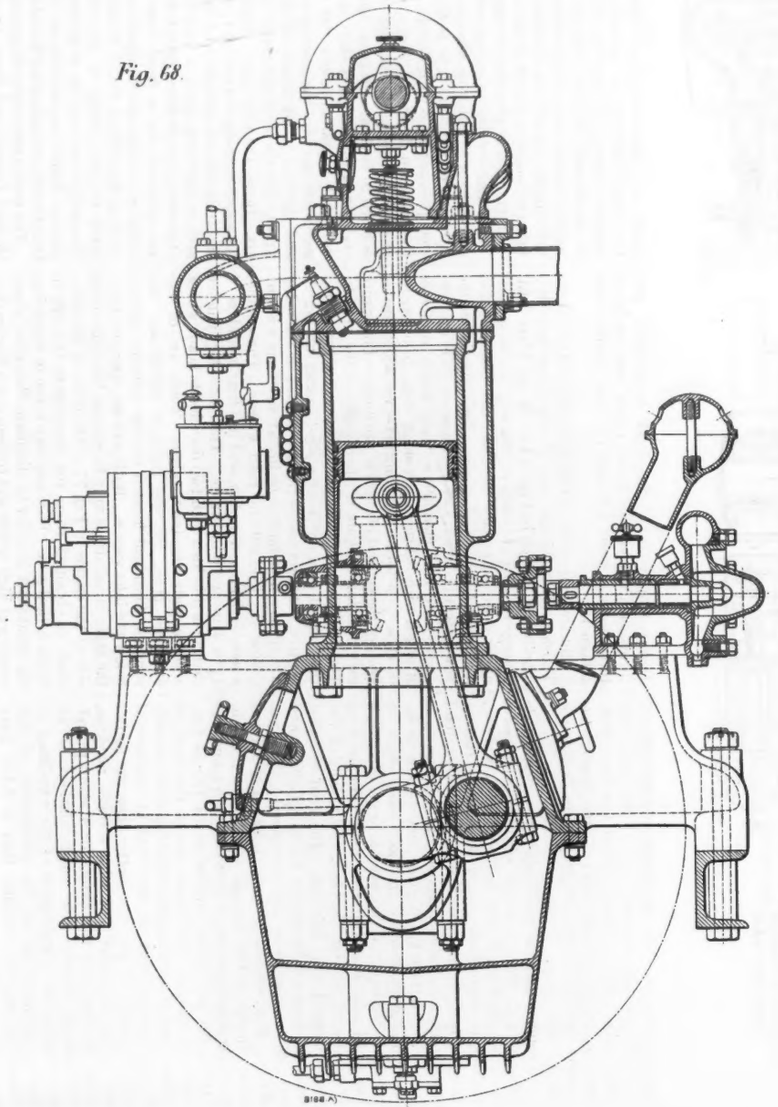


Fig. 69.

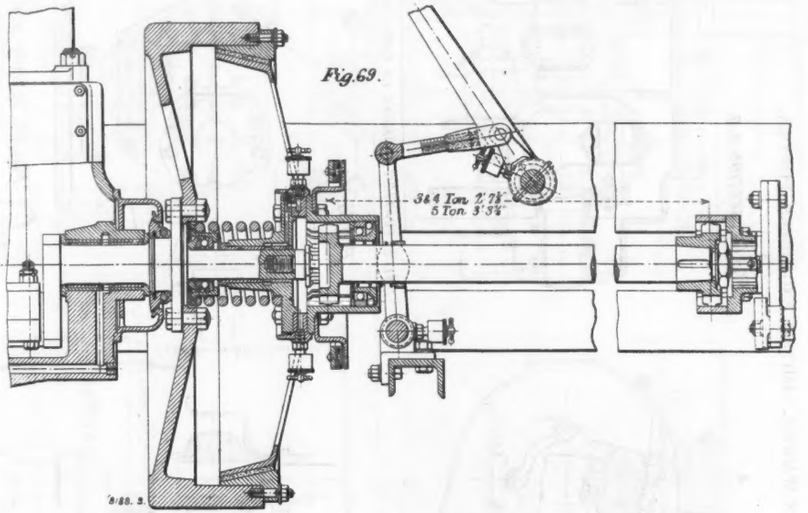
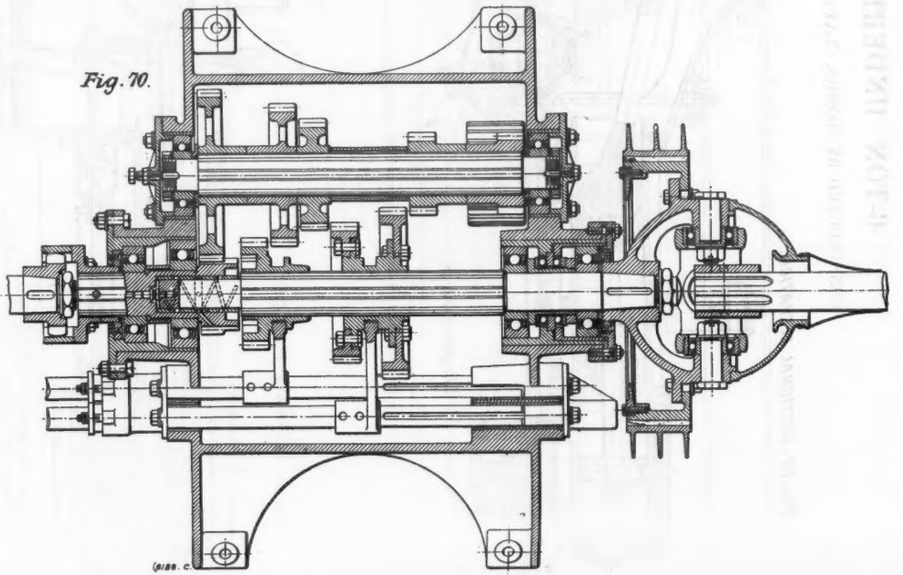


Fig. 70.



DETAILS OF MAUDSLAY OMNIBUS CHASSIS.

CONSTRUCTED BY THE MAUDSLAY MOTOR COMPANY, LIMITED, ENGINEERS, COVENTRY.

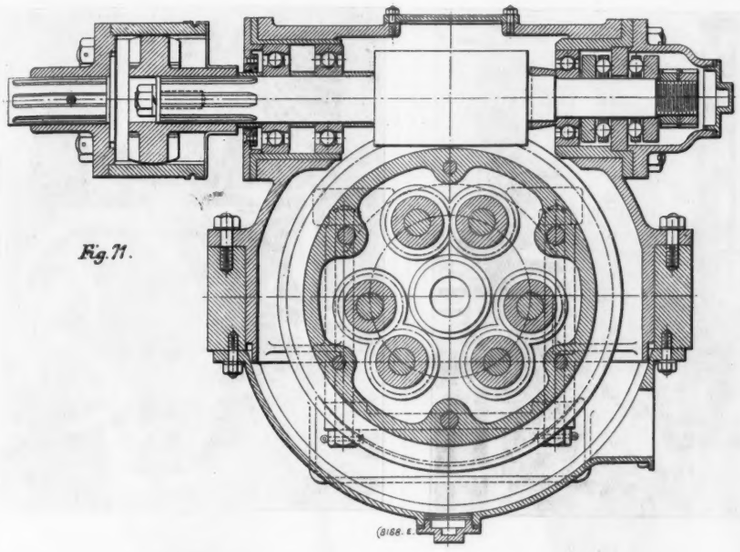


Fig. 77.

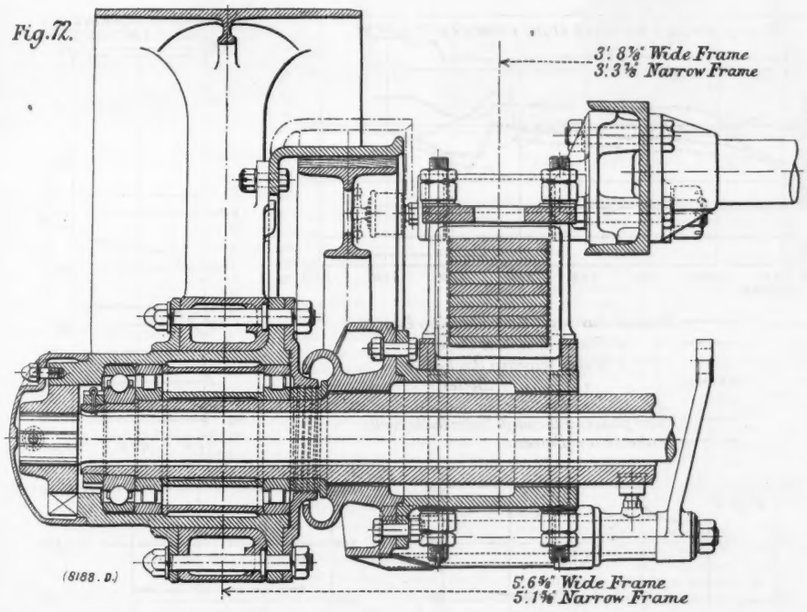


Fig. 78.

Fig. 80. The chassis is built up of pressed steel components, and on the front end there is a large vertical water-tube boiler, of which the tubes can be readily cleaned and, if necessary, withdrawn without having to take out the internal part of the boiler. This is made possible by removing a large square plate at the front, which leaves the tubes open for inspection or removal. The whole steam system has been designed for a working pressure of 250 lb. per square inch, and before the boilers are passed for use they are subjected in test to a pressure of 450 lb. per square inch. Within the smoke-box there is a superheater made up from solid-drawn steel tubes expanded into cast steel headers and of sufficient surface to give a steam superheat of 100 deg. F. A tubular type of feed-water heater serves to utilise the heat available in the exhaust steam for raising the temperature of the water injected into the boiler. The engine is of the horizontal double-acting type and consists of two high-pressure cylinders. As the valve gear is of the radial type, there are no eccentrics in its constructions. Two balanced piston valves are used to distribute the steam. These are of the well-known Garrett type, and were devised for working with superheated steam. A feed pump is located beside the engine, outside the chassis frame, and driven off the crankshaft through gearing. The control for this pump is fitted to the steering pillar. A specially-designed stop valve is provided on the boiler, and is operated through an accelerator pedal so that the quantity of steam passing to the engine may be regulated at any time. The transmission is effected through a two-speed gear and differential on a countershaft, beside the engine and two Hans Renold chains give the drive to the rear wheels. The brakes are placed side by side on each of the rear wheels. One is an internal expanding type, lined with Ferodo, which is operated by a side lever placed near the driver's right hand, while the other is of similar construction, but operated from a pedal.

The trailer shown in Fig. 80, Plate XLI, is also manufactured by Messrs. Richard Garrett and Sons, Limited and was designed for association with their steam wagon. It is of the tracking type. The frame is built up of pressed steel of channel section to which cross members of the same material are secured by fitted bolts in reamered holes. Great care has been shown in designing the interchangeable springing system for the chassis. All four wheels steer, the axles being of the Ackerman type. The connection of the front and rear axles is so arranged that the curves traced on the ground by the wheels when rounding curves coincide exactly, and also follow the tracks of the rear wheels of the towing vehicle. Brakes are fitted to the rear wheels and may be applied either from the ground by means of a lever and rachet or from the towing vehicle by a steel wire cable. Tipping gear of the Bromilow and Edwards' type may be applied to the trailer wagon as is shown in the illustration, and it is operated by the use of detachable and flexible pipes to convey the oil under pressure to the telescopic rams. Three-way tipping is available, the direction being controlled by the removal or reinstatement of the corner hinge brackets.

This year's Commercial Motor Transport Exhibition provided evidence of the great advance that has been made recently in the design and construction of this class of vehicle, a class which has become so important a factor in modern transport, either of goods or passengers. The industry has suffered through its heavy production during the period of the European War, but it is to be hoped that the increasing demands for economic transport will lead to a revival of trade in an industry in which the British products have so many outstanding merits.

THE CLARKSON WASTE HEAT BOILER.

THE thimble-tube type of boiler, originally designed by Mr. Thomas Clarkson, M.Inst.C.E., to meet the very difficult conditions of service under which the boilers of steam wagons have to work, has now been adapted to another kind of duty for which its special constructional features render it particularly suitable. The application to which we refer is the recovery of waste heat from the exhaust gases of gas and oil engines, for which the boiler also forms an effective silencer. Roughly speaking, one-third of the heat of the fuel in an ordinary internal combustion engine is turned into useful work, the remaining two-thirds being carried away to waste, half by the cooling water and half by the exhaust gases. The Clarkson boiler in which the already heated cooling water is used to abstract a large proportion of the heat from the exhaust gases, can be used either to provide an abundant supply of hot water, or alternatively a useful supply of steam, according to the manner in which is is operated. It requires, moreover, none of the personal attention which steam boilers demand, and the steam or hot water produced is obtained with no expense whatever for fuel.

A Clarkson waste heat boiler, as arranged for use in connection with a two-cylinder Vickers-Petter heavy oil engine, is illustrated in Figs. 1 and 2 on page 712, the appearance of the complete plant being shown in Fig. 3. The simplicity of the construction of the boiler will be understood from the drawings. It consists of two cylindrical shells one within the other. The upper part of each shell is closed by a domed end, and the open ends are connected by a bolted flanged joint. The space between the shells contains water and steam, and the hot exhaust gases from the engine circulate within the inner shell, the heating surface of the latter being increased by a large number of internally-projecting thimble-shaped tubes. These tubes extend from the wall of the inner shell until they are almost in contact with the gas outlet pipe in the centre, and as they are "staggered" vertically, the flow of the hot gases is most effectively broken up, and very favourable conditions for heat transmission are secured. The tapered form of the thimbles enables them to make a perfectly tight joint without being expanded into the shell-plate, and the boiler pressure tends to maintain this tightness. As they are held at one end only they can expand individually in accordance with variation in thermal conditions without imposing any strain whatever on the joints.

It has been found impossible to burn the tubes in a fuel-fired boiler, however fiercely the boiler was fired. The circulation in the tubes appears to be of a pulsating nature, steam being generated which can only escape by blowing the water back intermittently. This action seems quite effective in preventing deposit or scale in the tubes, and we believe that a boiler of the type in question has been used on a steam lorry for two years without having to be scaled. A baffle-plate situated between the inner and outer shells prevents feed water from impinging on the hot inner shell and facilitates the deposit of any lime in the water. In boilers working in conjunction with internal combustion engines, the hot jacket water of the engines is used as

WASTE HEAT-BOILER FOR OIL ENGINES.

CONSTRUCTED BY MESSRS. CLARKSON STEAM MOTORS, ENGINEERS, LONDON,

Fig. 1.

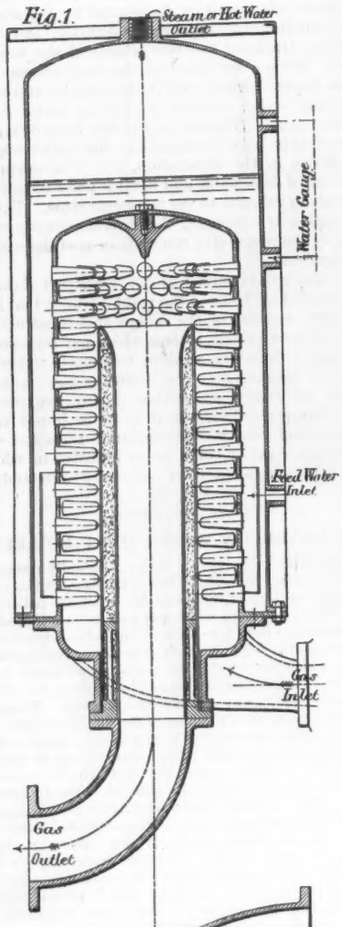
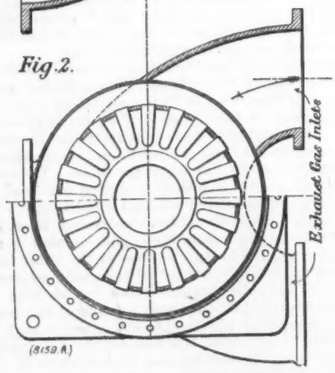


Fig. 2.



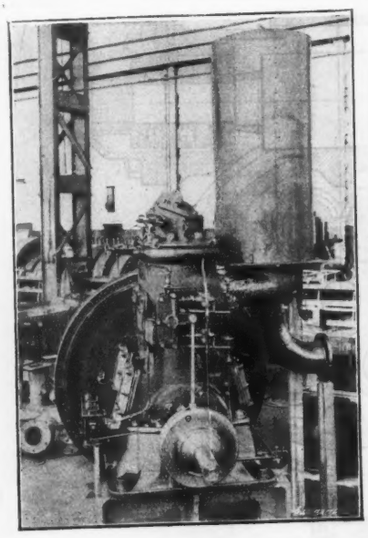


FIG. 3.

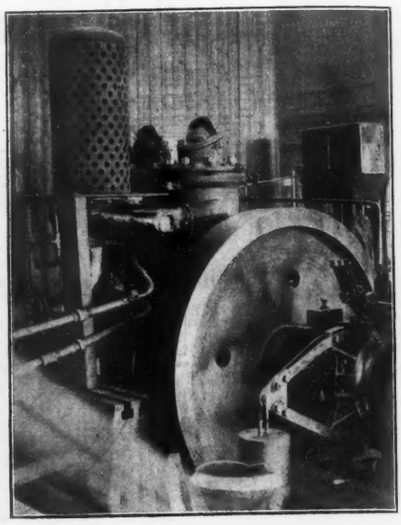


FIG. 4.

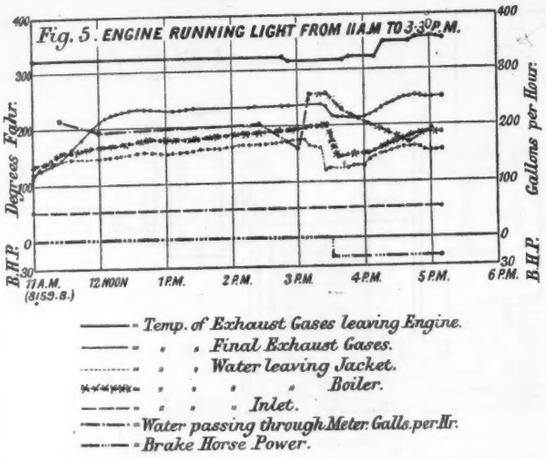
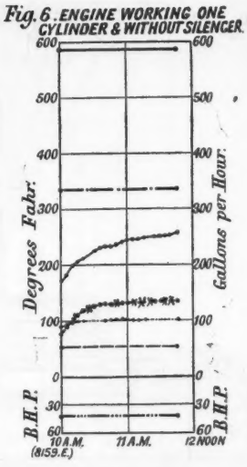
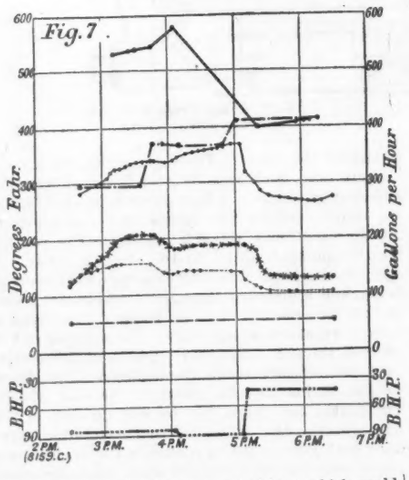
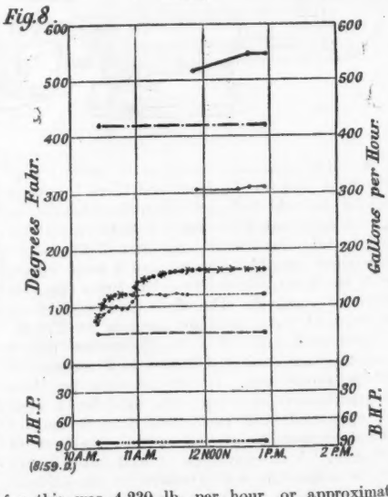


Fig. 5. ENGINE RUNNING LIGHT FROM 11 A.M. TO 3·30 P.M.
Degrees Fahr.
Gallons per Hour.
B.H.P.
11 A.M. 12 NOON 1 P.M. 2 P.M. 3 P.M. 4 P.M. 5 P.M. 6 P.M.
(8159.B.)
Temp. of Exhaust Gases leaving Engine.
Final Exhaust Gases.
Water leaving Jacket.
Boiler.
Inlet.
Water passing through Meter. Galls. per Hr.
Brake Horse Power.







feed. The level of the water in the boiler can be regulated by an automatic arrangement comprising a float chamber, external to the boiler, containing a float, the spindle of which is kept in a slow reciprocating motion. The effect of friction is thus entirely overcome, and the float is free to indicate the water level and to control the supply of water as though friction did not exist.

As will be seen from the illustrations, the waste-heat boiler is mounted upon a cast-iron connection arranged in very close proximity to the engine to minimise heat losses. The engine is of the two-stroke type, developing 84 brake horse-power, each cylinder being 12 in. diameter by 14-in. stroke. Fig. 3 shows the complete arrangement, while Fig. 4 shows the appearance of the inner part of the boiler after the outer shell has been removed. The observer is looking on the inside of the thimbles, the number and arrangement of which will be gathered from the illustration. The plant was constructed for the use of a large public institution, and very careful tests have been made upon it to determine the amount of heat which could usefully be recovered from the engine.

The water admitted to the cylinder jackets had a temperature of 54 deg. Fahr. and a pressure of 24 lb. per square inch. The flow was regulated in the first instance to obtain a discharge temperature from the jackets of about 120 deg. F. The rate of flow necessary for this was 4,230 lb. per hour, or approximately 5 gallons per brake horse-power hour. The rate of flow was subsequently reduced to 3,656 lb. per hour, or about 4·35 gallons per brake horse-power hour, and this had the effect of raising the temperature of the jacket water to 145 deg. F., and the water delivery from the boiler to 192 deg. F. The whole of the warm water

AUTOMATIC ELECTRIC MOTOR STARTING-GEAR.

CONSTRUCTED BY THE WATFORD ELECTRIC AND MANUFACTURING COMPANY, LIMITED, ENGINEERS, WATFORD.

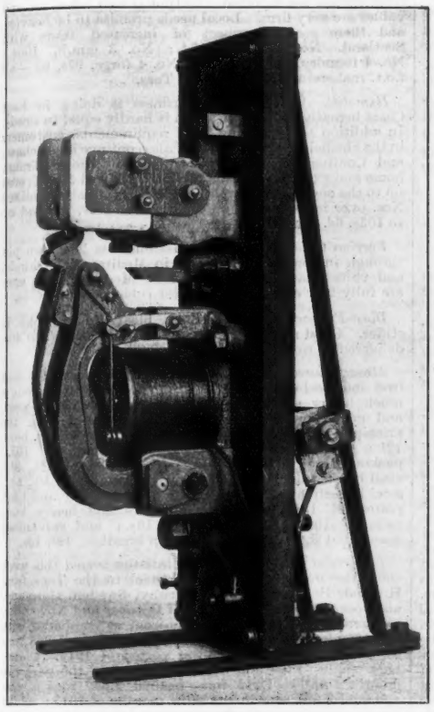


FIG. 4. CONTACTOR OPEN.

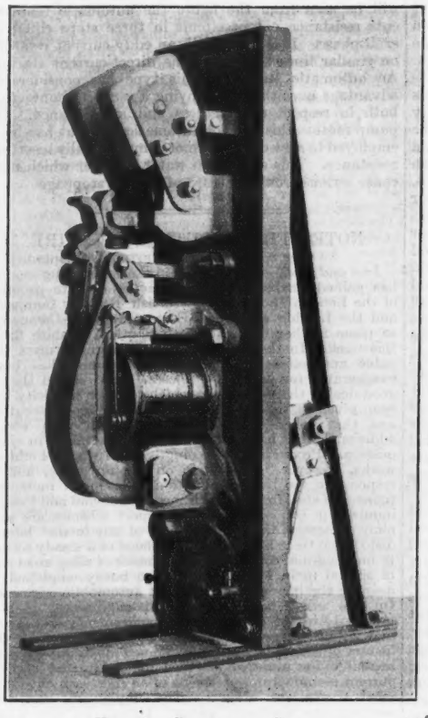


FIG. 5. CONTACTOR CLOSED.

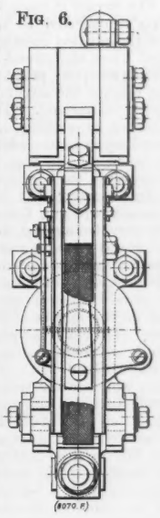


FIG. 6.

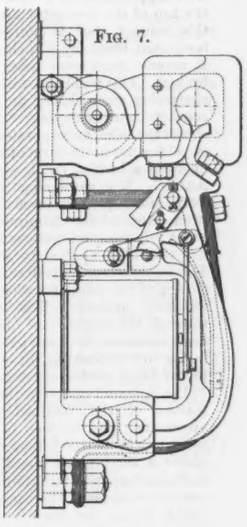


FIG. 7.

from the jackets and from the boiler, as well as the temperature of the gases before and after passing the boiler, were measured at short intervals. The temperature of the gases leaving the engine was 580 deg. F., the temperature readings being taken both by a thermometer, the naked bulb of which was in the path of the gases, and by a thermo-couple. Another thermometer in the path of the gases leaving the boiler showed that the loss in temperature due to the passage through the boiler was 300 deg. F. Water temperatures were all taken by thermometers having their bulbs in actual contact with the water. Readings of all thermometers were taken at five-minute intervals over periods of several hours. The quantity of water passing through the cylinder jackets and the boilers was measured by a tested meter on the inlet pipe, and the readings were corroborated by actual measurement of the hot water discharged from the boiler into a calibrated tank.

With the aid of the Clarkson boiler, nearly 60 per cent. of the waste heat of the engine was recovered. When some of the jacket water was by-passed, in order to reduce the feed of the boiler, the latter proved itself capable of delivering 26 cwt. of water per hour at boiling temperature. There was never any indication of back pressure on the engine exhaust, even when the engine was overloaded to 90 brake horse-power. At the full-load of 84 brake horse-power the oil consumption was a few per cent. better than before the boiler was fitted. The reason for the absence of back pressure, and the slightly improved consumption, is attributed to the fact that the boiler acts as a condenser for the exhaust gases, suddenly chilling them and reducing their volume, and thereby assisting their removal. The boiler also acted as an effective silencer.

With the engine developing its full load of 84 brake horse-power, and the whole of the water supply to the jackets, namely, 4,230 lb. per hour being delivered to the boiler, the following results were obtained on test. The engine consumed 44·52 lb. of oil per hour, of a specific gravity of 0·878 and a calorific value of 18,500 B.Th.U. per lb. This works out to a consumption of 0·53 lb. per brake horse-power hour. The heat developed per hour by the combustion of the fuel was 823,620 B.Th.U., and of this 300,330 B.Th.U., or 36·4 per cent. of the total was recovered from the jackets by raising the temperature of the water from 54 deg. F. to 125 deg. F. The Clarkson boiler recovered a further 169,200 B.Th.U., or 20·5 per cent., utilising this to raise the temperature of the water from 125 deg. F. to 165 deg. F. The total amount of the heat recovered therefore from the engine was 56·9 per cent. of the original heat of the fuel. On another test, with the flow of water regulated to 2,912 lb. per hour, the whole of this water was raised to boiling point, the percentage of heat recovered in this case being 56·9 per cent.

The diagrams reproduced in Figs. 5 to 8 on page 712 show graphically the results of typical tests on the combination which we have described. Each diagram shows the power developed, the initial and final temperature of the exhaust gases, the temperature of the feed water, of the outlet from the jackets, and of the outlet from the boiler, and the number of gallons of water per hour flowing through the engine. The charts are, indeed, self-explanatory, and are interesting particularly as showing the effect if any variation in the load. Fig. 5 refers to a test during 4½ hours of which the engine was running light, and it will be seen even in this case there is quite enough waste heat to provide a very useful amount of hot water.

A difficulty which has been experienced in the recovery of the waste heat on the exhaust from oil-engines is the deposition of tarry matters and soot upon the heating surfaces. Such a deposit is quite likely to occur owing to the chilling of the gases and condensation of the vapours by the relatively cold tubes, and its effect is to bring about a serious reduction in the rate of heat transmission. The cleaning of the tar and soot from the interior of an ordinary boiler is not easy, but the Clarkson type lends itself to an extremely simple method. The deposit can be set alight and burnt off without any injury to the boiler, and without causing the joints to leak. The thimbles may indeed be made bright red-hot without damage, since they are free to expand as they will. No harm will therefore occur if the exhaust gases are passed through the boiler with no water in the latter.

AUTOMATIC MOTOR STARTERS.

MOTOR starters and regulators of the ordinary face-plate or drum types meet the conditions of a large proportion of the electric motor applications of industry, but an important percentage remains which requires control gear of a more specialized form. Many of the more difficult problems which have to be met call for individual consideration and design, while even those cases which can be met by gear of a more or less standardised type within its class, require apparatus which is of a very different nature from the ordinary motor starter or controller of commerce. Many of the cases of the control of, say, printing presses, or lifts come within this class. This state of affairs has led to the rise of various specialising firms who have laid themselves out to deal with some of the more difficult problems of motor control not covered by the more standardised methods of the larger electrical firms. This class of work is one which lends itself well to specialised manufacture, since the individual study and attention, which so many of the problems of practice require, can best be given by those who make the subject their speciality.

Among the firms which have devoted themselves to problems of electric motor control an important position is held by The Watford Electric and Manufacturing Co., Limited, of Whippendell Road, Watford. This firm, which was founded in 1900, originally had works in Fulham, but in 1911 a move was made to the present factory which is of a single floor and modern type, and was purposely built by the firm for their particular type of manufacture. The Watford Manufacturing Company, have specialised to such a definite extent that all their designs are associated with a form of solenoid operated control gear, but this limitation must not be taken to imply that their apparatus is capable only of a limited range of application. Although their designs have not got the general appeal which is a deliberate feature of ordinary motor control gear, they none the less are capable of meeting the conditions of a very wide class of problem, and the products of the firm have been very extensively used in connection with the control of pumps, capstans, air compressors, lifts, printing machinery, &c. An interesting special application is for automatic electrode control in electric arc smelting furnaces.

Some of the firm's manufactures are illustrated in Figs. 1 to 7 above and on page 716. Of these, that shown in Fig. 1, page 716, incorporates two examples of the automatic solenoid gear to which we have already referred. The panel is an example of the firms' standard form of pump control panels, but is arranged for the control of two pumps and motors, the motors being operated by floats at different levels so that when the water has fallen to a definite point one pump starts up, and if the water level continues to fall, then, at a predetermined lower level, the second pump also starts up. A change-over switch is provided which enables the float connections to the motors to be changed over so that each pump can be caused to take its fair share of normal running. This switch is mounted externally to the control gear and is not shown in Fig. 1.

As will be gathered from the figure, the motors are of the direct-current type. Each is provided with a main switch and fuses at the bottom of the panel and a shunt field regulator at the top. The two sets of automatic starting gear are situated in the centre of the panel, the resistances connected with both the automatic starter and the shunt rheostat being fixed behind. Each starter consists of a contactor, designed to make and break circuit, and the automatic rheostat. The contactor is in each case mounted to the left of the rheostat in Fig. 1, while the apparatus itself is shown to a larger scale and in detail in Figs. 4 to 7 above. The

contactors which are used to a very large extent throughout the range of gear manufactured by the company are of substantial and accurate construction, a complete range of jigs and gauges being employed in connection with their manufacture. The arrangement of parts will best be followed from Fig. 7. The auxiliary solid copper contacts are carried by a member pivoted at the top of the contactor arm. The circuit is made on this contact, but is immediately transferred to the laminated brush by a rocking of the pivoted member. A reverse movement takes place when the circuit is broken. This rocking arrangement effectively prevents chattering when closing and also relieves the auxiliary contact from carrying current continuously. The contactor also incorporates another interesting and novel feature in the form of an auxiliary armature which operates a locking catch which can be seen in Figs. 4, 5 and 7. This catch effectively prevents the contactor from being pushed or shaken into contact. It has been designed for Admiralty work where gun fire or other vibrating influence must be provided against, and has also been applied to shipping and traction work. The lock does not interfere in any way with the normal closing of the contactor when it is energised, as the small auxiliary armature lifts immediately current flows through the closing coil and before the inertia of the main armature has been overcome. The catch is shown in its lower position, in which it prevents the contactor being pushed or shaken in, in Fig. 4.

The solenoid-operated rheostat, which is the special feature of the Watford Manufacturing Company's apparatus, may be seen in Fig. 1, but its details will probably be better followed from Fig. 2. This figure shows a three-phase panel, but the essential features of the automatic starter are the same as in the direct-current example. The appliance consists of a solenoid which during the operation of the panel is energised from an auxiliary contact on the contactor. The steel plunger of the solenoid is attached to a swinging arm which actuates the main rheostat bar. As the arm swings owing to the rise of the plunger the bar moves in an outward and upward direction, and makes circuit in turn with a series of rheostat carbons, which are carried in fixed sockets and pressed outward by springs. The current flows through studs mounted in the carbons, and through flexible connections to the sockets, from thence through the fixing studs to the various resistance tappings. During starting, each carbon carries the current for a very short interval until the next carbon provides an easier path through less resistance, this action continuing until all the starting resistance has been short-circuited on a laminated copper brush at the top of the stroke which is large enough to carry the current continuously. The movement of the contact bar ensures full face contact with each carbon, as sections of the resistance are cut out of the starting circuit. This feature of full face contact reduces sparking to a negligible quantity, as there is no local burning, which is practically unavoidable in the ordinary face-plate type of starter, where the entering edge is called upon to take the current increment on each step, instead of the whole face of the carbon as in the Watford design. The sliding movement of the contact bar also results in a self-cleaning action which maintains the working ends of the carbons flat and in good condition. A further advantage of the design is that there is no danger of sticking when switching off since each carbon block tends to push the contact bar to the off position.

In its original form this Watford starter was provided with an oil dash-pot to secure the necessary retarded starting action, but in more recent examples an interesting and very effective eddy-current brake has been used in place of the dash-pot. This is illustrated in Fig. 3 and can be seen in position on the starter in Fig. 1. The horizontal swinging arm of the starter which is operated by the solenoid plunger is formed with a toothed sector at its outer end. This sector gears with the wheel train which is shown in Fig. 3, and as the arm is lifted by the plunger the train is set in motion and rotates an aluminium disc between the poles of an electro-magnet, producing an eddy-current braking effect which is independent of friction and temperature variation. By swinging the poles of the electro-magnet so that they do not embrace the disc so fully, an adjustment is provided by means of which the starting time may be varied over wide limits. The electro-magnet may also be fitted with a series coil by means of which the braking effect and consequently the starting time is automatically varied in accordance with the starting conditions, a heavy load resulting in a longer starting time than when the motor is starting against a lighter load.

The general features of the Watford starter when applied for alternating-current work are similar to those described for direct-current work with, of course, minor modifications dictated by the different current conditions. The panel illustrated in Fig. 2 is for the control of a three-phase motor with a wound rotor. The gear is of a simple type and consists of a three-pole contactor for the stator circuit and a Watford automatic rheostat for the rotor resistance circuit. The contactors have adjustable hinged fulcrums which arrangement acts as an effective silencer and eliminates the unpleasant hum which is sometimes associated with gear of this class. The contactors also embody the duplicate current-carrying contacts to eliminate chattering which have already been described. As will be seen from the figure the automatic rehostat cuts resistance out of circuit in three steps equal in each phase. It is fitted with an eddy-current retarder on similar lines to that of the direct-current starter. An automatic starter of this type has considerable advantage over those employing a series of contactors both in respect of quietness and maintenance. On pump motors this type of automatic rheostat has been employed to slow down the motor by gradually inserting resistance. This eliminates water hammer which may cause serious trouble in case of sudden stoppage.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The position in the engineering section has gained further strength from the definite promise of the London Midland and Scottish Railway Company and the London and North-Eastern Railway Company, to place further contracts with South Yorkshire firms this week. In the opinion of many manufacturers the value and extent of new railway business has been exaggerated for political purposes. It is stated that a good deal of the work about which so much publicity has been given in the lay press has already been executed, and that other contracts in connection with which additional work has been promised are actually in commission. Production at locomotive and wagon building works, however, is definitely on the up grade, and is responsible for the consumption of a much increased tonnage of steel from local furnaces. Colonial and foreign inquiries in connection with transport schemes are also more numerous, and in the absence of any further labour dislocation there is a definite likelihood of a steady return to more normal conditions. Producers of alloy steel and of special fittings and castings are busily employed in meeting the increased demands of automobile engineers. On the other hand agricultural engineering is still uniformly in the dumps. The requirements of Lincoln and Grantham are probably at the lowest ebb in the history of the trade, and with so much modern machinery available for purchase at auctions below the cost of current manufacture, prospects of an increased output at local works are obscure. The implement and tool sections are decidedly patchy, though on the whole makers are able to report a larger business with overseas customers. A diminution in German competition has given a fillip to home buying. Promising inquiries have been received from the South American Republics, the United States, France, Australia and New Zealand. Activity is most pronounced in edge tools, quarry tools, files, hammers and saws. In raw and semi-finished materials soft basic billets have advanced 5*s.* to 8*l.* 15*s.* per ton. Inquiries are in circulation for deliveries of increased tonnages of hematites and basic pig-iron over periods varying from three to six months. Lincolnshire works are operating full time and are offering little competition locally.

South Yorkshire Coal Trade.—While official quotations are unaltered, most of the house coal pits in this district have advanced prices of best household qualities 1*s.* per ton from December 1. This follows a rush of orders directly traceable to the advent of wintry conditions. Export trade in best steams is maintained at a high level with Continental consumers. Home railway companies continue to put increased tonnages into reserve. Lancashire trade is improving in slacks, and electricity concerns are in the market for increased contract supplies. Quotations:—Best handpicked branch, 31*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 21*s.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

Wireless Apparatus for Ships' Lifeboats.—The Marconi wireless set with which a demonstration was recently given at Gravesend before the Seafarers' Joint Council, a considerable advance upon previous apparatus of this class, in that the range has been increased, the arrangement of the masts and aerials has been improved, adequate shelter for the apparatus and operator has been provided, and the type of receiving apparatus used enables the direction of a rescuing ship to be determined with good accuracy. The set includes a ¼ kw. 600-metre spark transmitter with a range of at least 50 miles over the sea, and a directional receiver with which an ordinary open aerial is employed in conjunction with a frame aerial. The latter serves to indicate the direction of the line on which the rescuing ship is situated, but is not of itself sufficient to show whether the boat is heading towards or away from the ship. This can, however, be determined by the two aerials in combination, and it is thus possible for the boat to transmit to the ship the course the latter should steer to pick up the boat. The whole of the wireless equipment, with the exception of the masts and aerial, is contained in a weatherproof case, which only reduces the seating accommodation of the boat by two persons, and its weight is equal to the official allowance for two men. The apparatus is supplied by the Marconi International Marine Communication Company, Limited, Marconi House, Strand, London, W.C.2.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Home demand for Cleveland pig-iron is steadily growing, and a few inquiries from abroad are reported. Output is well taken up, and values are very firm. Local needs promise to be heavier, and there seems prospect of increased trade with Scotland. No. 1 is 107*s.* 6*d.*; No. 3 g.m.b., 100*s.*; No. 4 foundry, 98*s.* 6*d.*; and No. 4 forge, 97*s.* 6*d.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Quite a brisk business is doing in East Coast hematite, supply of which is hardly equal to needs. In addition to expanding local requirements, customers in the Sheffield district, and in Wales continue to purchase, and Continental inquiries are better. The minimum home and export quotation for Nos. 1, 2 and 3, delivered up to the end of the year, is now 101*s.* 6*d.* Sales of mixed Nos. over next quarter are reported at 102*s.* 6*d.* and up to 103*s.* 6*d.* is asked.

Foreign Ore.—Very substantial business has been put through in foreign ore, chiefly in Mediterranean kinds, and values have moved up. Best Mediterranean ores are fully 23*s.* c.i.f. Tees, and best rubio is quoted 25*s.*

Blast-Furnace Coke.—Durham blast-furnace coke is stiffer. Good medium qualities run from 38*s.* 6*d.* to 40*s.* delivered to works of local users.

Manufactured Iron and Steel.—Order books of finished iron and steel manufacturers are understood to present a much better appearance than at any time this year, and good inquiries are still circulating. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, joists and heavy steel rails, 9*l.* 10*s.*; fish plates, 12*l.* 10*s.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 19*l.* 10*s.*

Imports of Iron and Steel.—Statistics issued this week show the imports of iron and steel to the Tees from Holland, Belgium, France, Norway, Sweden, Germany, and coastwise, for the months of October and November, to have been 2,556 tons of pig-iron, as compared with 350 tons for the same months a year ago, and 268 tons for the corresponding pre-war period of 1913. Plates, bars, angles, rails and sheets imported in the past two months totalled 1,215 tons, against 1,349 tons a year ago, and 3,601 tons in the same months of 1913; whilst the imports of crude sheets, bars, billets, blooms, and slabs amounted to 13,503 tons, as against 10,488 tons a year ago, and 10,986 tons in 1913.

Tees Iron and Steel Shipments.—Shipments of iron and steel from the Tees during November totalled 104,040 tons, 32,040 tons being pig-iron, 1,996 tons manufactured iron, and 70,004 tons steel. Of the pig-iron shipped 27,424 tons went abroad, and 4,616 tons went coastwise; of the manufactured iron loaded 1,888 tons went abroad, and 108 tons went coastwise; and of the steel cleared 60,229 tons went abroad, and 9,775 tons, went coastwise. The principal buyers of pig-iron were: Italy, 4,823 tons; Belgium, 4,503 tons; France, 3,785 tons; Scotland, 3,250 tons; Sweden, 2,870 tons; Denmark, 2,683 tons; Germany, 2,657 tons; and America, 2,650 tons. Egypt and India were the chief purchasers of manufactured iron, the former taking 574 tons and the latter 568 tons. India was by far the heaviest importer of steel, receiving 27,939 tons.

Patents in Italy.—A new patent law, shortly, it is understood, to be introduced in Italy, will provide for a uniform term for patents of 15 years from date of application. All documents will be required to be in the Italian language, and renewal fees will become due within a month of application.

Mine Timber in Pennsylvania Coal Mines.—The Pennsylvania anthracite region, considered as a single mining district, is by far the largest user of mine timber of any mining district, either coal or metal, in the United States, and the bituminous districts of Pennsylvania rank second. The present annual consumption of mine timber by the coal mining industry of Pennsylvania probably exceeds 100,000,000 cub. ft. annually. In 1919 Pennsylvania produced, in round figures, 145,300,000 tons of bituminous coal, 86,200,000 tons of anthracite, and 5,400,000 tons of iron ores. If it be assumed that the bituminous coal mines required 0·33 cub. ft., anthracite mines 0·7 cub. ft. and iron mines 0·9 cub. ft. per ton mined, the timber requirements were: bituminous, 47,950,000 cub. ft.; anthracite, 60,340,000 cub. ft.; iron mines, 4,860,000 cub. ft.; or a total of over 113,000,000 cub. ft. The average cost of round mine timber in the anthracite region in 1905 was, according to the United States Forest Service, 6·6 cents per cubic foot, and 15 dol. per 1,000 board feet for sawed timber. The present cost has advanced to 27·5 cents per cubic foot for round timber, delivered to the mine, of which cost 57·3 per cent. represents freight charges. It is reported that some anthracite operators have had trial shipments of Douglas fir brought by ships from Oregon by way of the Panama Canal, with a view to trying out the use of Douglas fir for certain places in the mine, in competition with the timbers now obtainable from the near-by Southern States, which consist mostly of mixed lots of various hardwoods, white and red oak, chestnut, beech, birch, maple, cherry, locust, red gum and other hardwoods.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Despite every endeavour to induce buyers to enter the field again the Scottish steel trade is not improving very rapidly. Circumstances are all against expansion this week owing to the great uncertainty in the political situation. Free trade, tariffs and a capital levy, but particularly the first two, are upsetting the majority of the people at present, and business will not settle down until the election is over and the future policy determined. Bookings during recent weeks amounted to a fair tonnage, and the reopening of the shipyards is largely responsible for the improvement with the result that employment at the various steel works is much better and the outlook overall is more promising. Inquiries have also increased, and when the disturbing political factor is removed there is the prospect of business opening out considerably. Plate mills are doing better and there is quite a good output of structural sections. Sheet makers are putting through a big tonnage of the lighter gauges, and the demand for heavy sheets is much above what it has been for some months past. Galvanised sheets continue in good request and fairly active conditions are general. Prices are steady and are quoted as follow :—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable iron trade is just the turn better, and although dealing has not improved to any appreciable extent the outlook is rather better. The political upheaval has made business very sticky this week, and as the great question to be decided is so momentous men's minds are, in many cases, quite off the regular run of business. Conditions will soon sort themselves out, however, and a gradual improvement is anticipated. Things in the re-rolled steel bar branch continue fairly satisfactory. Prices are without change and "Crown" bars are still 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—There is more business passing in the Scottish pig-iron trade with home consumers, and there is again more disposition to contract forward. This is the case both in hematite and foundry grades of iron, and stocks are being reduced slowly. The export trade is maintaining a fairly steady level and the general inquiry is quite good at present. Prices keep rising and some producers are asking and obtaining higher prices than are supposed to be the current rates. The following may be taken as to-day's quotations :—Hematite, 5*l.* 7*s.* 6*d.* per ton delivered at the steel works; foundry iron, No. 1, 5*l.* 10*s.* per ton, and No. 3, 5*l.* 5*s.* per ton, both on trucks at maker's yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, December 1, amounted to 2,022 tons. Of that total 1,942 tons went overseas and 80 tons coastwise. For the corresponding week of last year the figures were 2,342 tons foreign and 71 tons coastwise, making a total shipment of 2,413 tons.

Shipbuilding.—The most important fact to be noted this month is the settlement of the dispute with the boilermakers, and the re-opening of the majority of the shipyards. The booking of quite a number of contracts recently has materially improved the position, as without these the restart would have been much smaller all round. It takes a considerable time to absorb the normal number of men, and the unemployment in shipyard workers and the allied trades has not been greatly reduced as yet. The prospect of a few of the light cruisers which the Government propose ordering coming to the Clyde will help things considerably, as many men will be re-engaged, and there is also the possibility of some orders for cargo boats in the near future, and the outlook is therefore much better. The output from the Scottish yards for last month was very poor indeed, and consisted of 11 vessels totalling 5,084 tons, all of which, except 3 small boats of 50 tons launched in the Dee and Moray Firth area, were Clyde built. The Clyde total for the year to date is now 99 vessels of 172,275 tons, a very low output indeed, and to find a sequel we must go back some thirty or forty years. Last year we had a total for the eleven months of 114 vessels, of 369,326 tons, and a high-water mark in the year 1913 of 238 vessels of 628,816 tons for the same period, but we must not forget the boilermakers' lock-out of six months during the current year.

WHITWORTH SOCIETY.—The first commemoration dinner will be held on Friday, December 21 (being the anniversary of the birth of Sir Joseph Whitworth, Bart.), in the Royal Venetian Room at the Holborn Restaurant, London, W.C.1. Reception by the President, Dr. H. S. Hele-Shaw, at 7 p.m. for 7.30 p.m. Application for tickets should be made to the Hon. Secretary, Whitworth Society, c/o The Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1.

ATMOSPHERIC CORROSION.—The first experimental report to the Atmospheric Corrosion Committee of the British Non-Ferrous Metals Research Association will be presented and discussed at a meeting of the Faraday Society to be held on December 17 at 8 p.m. in the rooms of the Chemical Society, Burlington House, W. 1. The very comprehensive series of field tests and laboratory experiments described in the report were carried out by Mr. W. H. J. Vernon on behalf of the Committee. Persons interested in the subject desirous of attending the discussion may obtain a ticket of admission from the Secretary, Faraday Society, 10, Essex-street, W.C.2.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 8, at 3 p.m., in the Royal Technical College, George-street, Glasgow. The following papers will be discussed: Mr. Joseph Parker's paper on "Economy and Efficiency of Ventilation," Mr. H. M. Cadell's paper on "A Volcano in the Bathgate Coalfield of West Lothian," Mr. David Ferguson's paper on "The Hurlet Sequence in Renfrewshire and Dumbartonshire, and the Evidence of Basin Structure in the Coalfields of Scotland," and Mr. William G. Burt's paper on "Coal Conveyors."

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, December 10, 1923, in the hall of the Cleveland Technical Institute, Corporation-road, Middlesbrough, at 6.30 p.m. Paper on "Low Temperature Treatment of Coal with Bye-Product Recovery," by Mr. W. Beswick and Mr. A. T. Grisenthwaite.

ROYAL SOCIETY OF ARTS.—Monday, December 10, at 8 p.m.: Cantor Lecture, "Recent Progress in the Wool Industries, by Aldred F. Barker, M.Sc., Professor of Textile Industries, The University, Leeds. (Lecture II.) Wednesday. December 12, at 8 p.m.: Ordinary Meeting, "The Preservation of Historic Buildings and Ancient Monuments," by Sir Frank Baines, C.V.O., C.B.E., Director of Works, H.M. Office of Works. Sir Aston Webb, K.C.V.O., C.B., P.R.A., Vice-President of the Society, will preside.

NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, December 10, at 5.30 p.m., at the Northampton Engineering College, St. John-street, E.C. 1, Paper on "Relativity," by Mr. F. M. Denton, A.C.G.I., M.I.E.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: MERSEY AND NORTH WALES (LIVERPOOL) CENTRE.—Monday, December 10, at 7 p.m., at the Laboratories of Applied Electricity, The University, Brownlow-street, Liverpool. Joint Meeting with the Liverpool Engineering Society, when a paper will be read on "Pulverised Fuel and Efficient Steam Generation," by Mr. D. Brownlie, B.Sc.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Monday, December 10, at 7.30 p.m., in the Rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Paper on "Cold Working of Metals, and its Influence on the Properties and Uses," by A. T. Adam.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, December 11, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Paper on "Admiralty Gun-Metal," by Mr. S. G. Homfray and F. Adam.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, December 11, at 7 p.m., in the Chamber of Commerce, New-street. Paper on "Extrusion Problems," by Major R. M. Sheppard.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 11, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when a discussion on "Some Applications of Illuminating Engineering in Practice" will be opened by Mr. Geo. Herbert and Mr. R. A. Ives.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, December 11, at the Royal Society of Arts, John-street, Adelphi, W.C. 2, the following paper will be read, "The Modern Rotary Drilling System," by Mr. L. R. McCollum. The chair will be taken at 5.30 p.m. by the president, Mr. H. Barringer, M.Inst.C.E., M.I.Mech.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, December 11, at 7.30 p.m., at the Rooms, 207, Bath-street, Glasgow. Paper, "Pulverised Fuel and Efficient Steam Generation," by Mr. D. Brownlie.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, December 11, at 6.30 p.m., Adjourned Discussion on the paper read at the Shipping and Engineering Exhibition, by Mr. E. W. Blocksidge, on "Life-Saving Appliances on large Passenger Steamers."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 11, at 6 p.m. Paper to be further discussed: "The Bio-Aeration of Sewage," by Mr. Arthur John Martin, M.Inst.C.E. Informal Meeting, Wednesday, December 12, at 7 p.m. Subject for discussion :—"The Lighting of Factories," to be introduced by Mr. Walter Paul Frederick Fanghaenel, B.Sc., and Mr. William Newton Booth, B.Sc., Assoc.M.M.Inst.C.E. Students' Visit: Wednesday afternoon, December 12, to the Works of the Express Lift Company, Limited, Greycoat-street, Westminster, S.W. 1.

THE INSTITUTION OF WATER ENGINEERS.—Tuesday, December 11, at 2.30 p.m., and on Wednesday, December 12, at 10.30 a.m., at the rooms of the Geological Society, Burlington House. The chair will be taken by Mr. H. C. Head, M.Inst.C.E., M.I.Mech.E., and the following papers will be read and discussed: "The Somerford Pumping Station, South Staffs. Waterworks Company," by Mr. Frederic J. Dixon, M.Inst.C.E., M.I.Mech.E., F.R.S.; "Waterworks Supply Legislation," by Mr. Percy Griffith, M.Inst.C.E., M.I.Mech.E., F.G.S., F.R.San.I.; "A Comparison between British and American Waterworks Practice," by Mr. G. Mitchell, M.Inst.C.E., M.I.Mech.E., F.G.S. Lecture by Mr. H. J. F. Gourley, M.Eng., M.Inst.C.E., F.G.S., on "The Geology of the Catskill Scheme, New York."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): MANCHESTER CENTRE.—Wednesday, December 12, at the College of Technology (Room C. 2), Sackville-street, Manchester, at 7 p.m., when a paper will be read by Mr. F. W. Attock, Member, on "Locomotive Shed Lay-Out," which will be followed by discussion.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, December 12, at 2.30 p.m., at University College, Gower-street, London, the following paper will be read and discussed: (*a*) "An Apparatus for the Calibration of Burette Tubes," by Mr. Verney Stott, B.A., F.Inst.P.; (*b*) "Some Factors Affecting Efficiency in the Glass Trade," by Mr. Eric Farmer, M.A. (Industrial Fatigue Research Board); (*c*) "Specifications in the Glass Industry, with Special Reference to Soda Lime Glasses for Containers," by Professor W. E. S. Turner, D.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 13, at 6 p.m., "Pulverised Fuel and Efficient Steam Generation," by Mr. D. Brownlie.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, December 13, at 8 p.m., in the Rooms of the Institute of Marine Engineers, 85-88, The Minories, Tower-hill, E. 1. Paper on "Some Foundry Problems," by Mr. A. H. Mundey. (Joint meeting with the Institution of British Foundrymen.)

THE INSTITUTION OF ENGINEERING INSPECTION.—Thursday, December 13, at the Royal Society of Arts, John-street, Adelphi, Mr. William Allsup, A.M.I.Mech.E., M.I.E.I., will read a paper on "Gauging, Gauge Design and Inspection," with Lantern Slides and Exhibits. The chair will be taken at 8 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 14, at 7.30 p.m., at 39, Victoria-street. Lecturette, "The L.C.C. Regulations for Steel-Framed Buildings," by Mr. S. Bylander (Past Chairman).

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, December 14, at 7.30 p.m., in the Non-Ferrous Lecture Room of the University, St. George's square. Paper on "The Metallurgical Microscope—Some Notes on Its Construction and Use," by Mr. J. H. G. Monypenny.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, December 14, at 7.15 p.m., in the Metallurgical Department, University College, Singleton Park. Paper on "Some Applications of the Brinell Hardness Test," by Mr. A. L. Norbury, M.Sc.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 14, at 6 p.m., "Exhaust-Valve and Cylinder-Head Temperatures in High-Speed Petrol Engines," by Professor A. H. Gibson, D.Sc., Member, and H. Wright Baker, M.Sc. Graduates' Section, London: Monday, December 17, 1923, at 7 p.m., "The Management of a Sand and Flint Quarry," by Mr. F. E. A. Manning, Student, of London. Chairman, Mr. E. W. Monkhouse, Member.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The Welsh coal trade has once again been disorganised by arbitrary action on the part of a section of the men engaged in the loading of coal at the docks. It will be recalled that six months ago an agreement was arrived at between the coal trimmers, tippers and the employers, after protracted negotiations, to work a partial third shift for an experimental period of six months. This agreement contained a clause in which the men and the employers in the case of any difference arising agreed to refer the matter to the Court of Inquiry, appointed by the Minister of Labour, to go into the question of whether a third shift was necessary. In the middle of last month a joint delegate conference of Bristol Channel coal trimmers and tippers sent a resolution to the headquarters of their respective unions intimating that they wished the third shift to cease at the expiration of the experimental period and requested that a conference should be arranged with the employers to discuss the matter. No such conference was arranged because of the political activity of the headquarters officials, and the question of the third shift was allowed to drift without any agreement being reached in respect to its continuation or cessation. Over the week-end the tippers of Cardiff, Penarth and Barry at separate meetings decided that they would not continue to work by night, notwithstanding that the trimmers had agreed to continue the third shift pending a joint conference with the employers after the general election. The tippers at Newport, Swansea and Port Talbot remained at work. The result was that night working was suspended at Cardiff, Penarth and Barry, as the coal trimmers were unable to work without the tippers, and further complicated matters by deciding not to resume the third shift until the question was settled by a joint conference of representatives of the men and the employers. The result of the men's action is that boats are again suffering detention; and at present there are no less than 46 vessels waiting for loading berths, and it is believed that if the stoppage is continued the docks will become congested, and ships will once again be compelled to swait in the various roadsteads their turn to enter the docks. Meanwhile the coal market is much firmer, and buyers are experiencing difficulty in securing supplies. Best Admiralty large is now round 29*s.* 6*d.* with the leading Monmouthshires from 28*s.* to 28*s.* 6*d.*, while best steam smalls are now very scarce and firm at 22*s.*, with the inferior grades from 16*s.* Cokes are also strong at 50*s.* to 57*s.* 6*d.* for foundry sorts, but patent fuel continues inactive but steady at 29*s.* to 32*s.*

The Iron and Steel Trades.—Exports of iron and steel goods from South Wales last week amounted to 19,217 tons compared with 13,814 tons in the preceding week. Of the total tin plates and terne plates represented 11,909 tons, compared with 4,966 tons; black plates and sheets to 5,969 tons, against 5,655 tons; galvanised sheets to 1,188 tons, against 8,010 tons, and other iron and steel goods to 151 tons, compared with 2,372 tons.

AUTOMATIC ELECTRIC MOTOR STARTING-GEAR.

CONSTRUCTED BY THE WATFORD ELECTRIC AND MANUFACTURING COMPANY, LIMITED, ENGINEERS, WATFORD.

(*For Description, see Page* 713.)

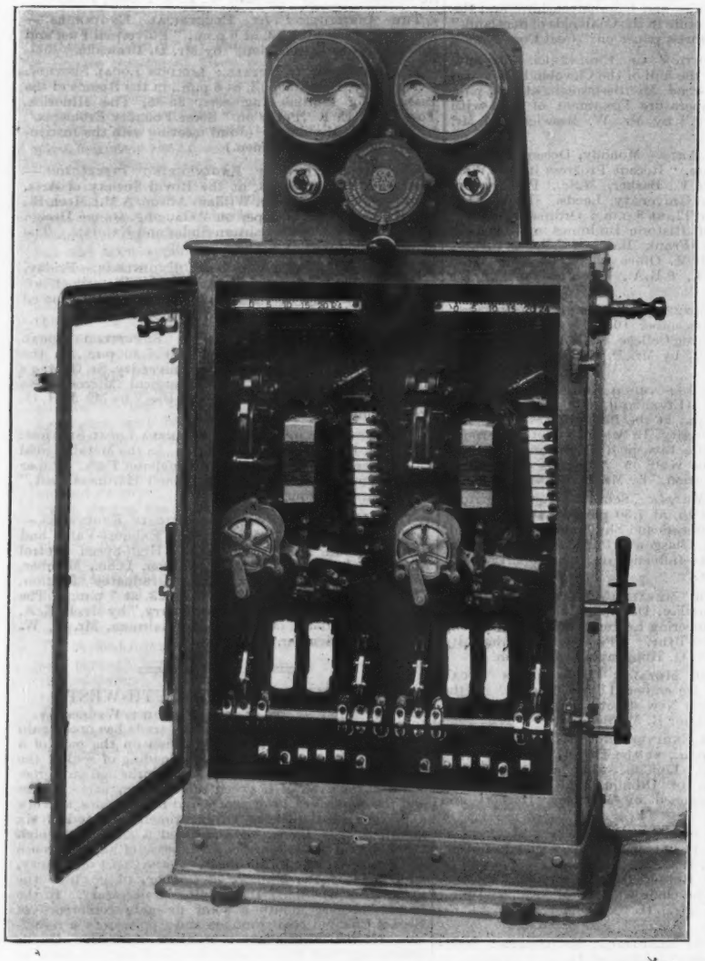


FIG. 1. D.C. STARTING PANEL FOR TWO PUMP MOTORS.

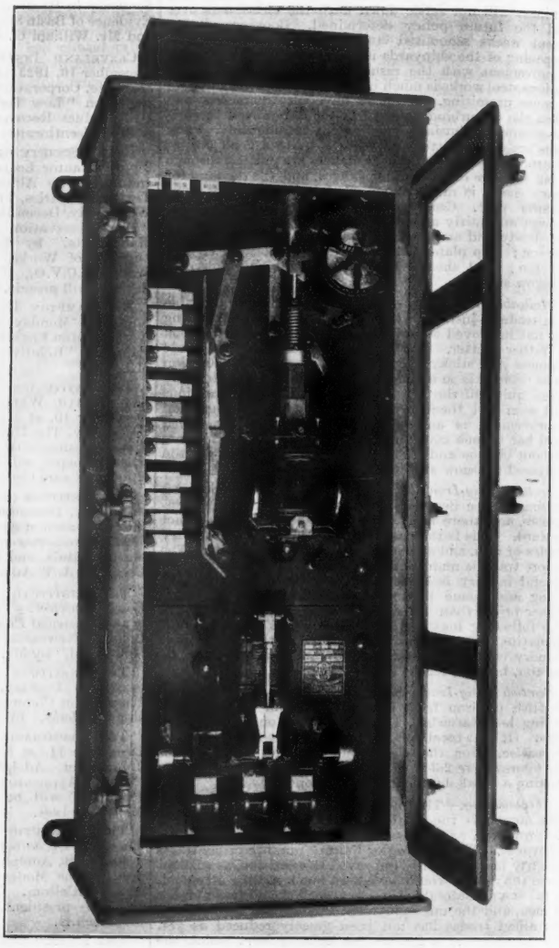


FIG. 2. A.C. STARTING PANEL FOR THREE-PHASE MOTORS.

CORROSION, HEAT AND ELECTRICITY RESISTANT ALLOYS.—A conference of the American Society for Testing Materials was held at Philadelphia on October 24, when it was decided that the time was not opportune for the preparation of standard specifications for these alloys, since new alloys and new uses are being developed to such an extent that the framing of standards would probably retard progress.

LIGHTNING AND FIRES.—The United States Department of Agriculture estimates the damage done by fires traced to lightning at 20,000,000 dollars annually. In the State of Iowa alone such fires caused damage amounting to $1,363,700 in the four years 1918 to 1922; 61 per cent. of this loss was due to the burning of farm barns and most of it might have been prevented, it is thought, by providing suitable lightning conductors.

AN ENGINEER'S TOOLS ENCYCLOPÆDIA.—A volume of over 1,000 quarto pages, well printed, illustrated and bound, has recently been brought out by Messrs. Buck and Hickman, Limited, 2-6, Whitechapel-road, London, E.1, under the title of "Tools and Service." The compilation forms a general catalogue of engineers' small tools and supplies, and is so complete that we are sure the hope of the firm that it may prove of service to their friends in all parts of the world, cannot fail to be realised. The volume does not cover machine tools in the ordinary sense, but a number of machines which come very nearly within that category are included. The variety and range of articles dealt with is exceptionally good, giving distant customers a wide choice in nearly every section, while the illustrations and data given form excellent guides to the special features of each pattern of any given article. Though fluctuating, only in a few cases are prices omitted, and engineers abroad will find the volume of great assistance in reducing delays due to inquiries. The book further contains formulæ, conversion factors and tables and other serviceable data, which are sure to make it a welcome addition to many an engineer's office.

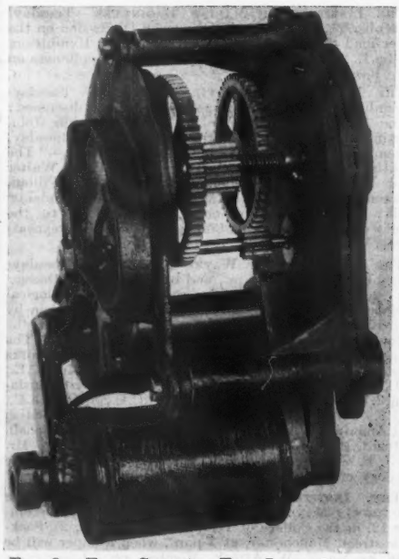


FIG. 3. EDDY-CURRENT TIME-LIMIT DEVICE.

CORRUGATED PIT TUBS.—Some time ago Messrs. Robert Morris and Co., Atlas Works, Farnworth, near Bolton, introduced a pattern of pit tub made of corrugated steel plate which has been largely adopted, owing to the success with which it withstands rough usage. This tub is now well known at home, but it may be pointed out that it presents considerable advantages for use abroad owing to the facility with which it can be assembled by unskilled labour. As is well known, the tub body consists of five sheets which are joined together by four corner bolts and four binding pins. No rivets whatever are used. The sheets pack snugly, and ship as bundles of sheets at well below 40 cub. ft. per ton, thus ensuring favourable freight charges. The only tools necessary for assemblage are a hammer and a spanner, and these in the hands of a labourer, single-handed, will enable the tub to be put together in about 5 minutes. This compares with some hours' work required for a riveted steel, or wooden, body. In the matter of repairs the sheets are interchangeable, and unskilled labour can again be employed, but as is well known, among the claims for this type of body are long life and low maintenance owing to the stiffness of the corrugated construction. The corrugations of the ends and sides are staggered, if we may use the expression, so that the ridge of a side is on a level with the valley of an end, and *vice versa*. The result is that at the flanged corners the corrugations in the ends change from ridge to valley, and valley to ridge, making a corner for which no stiffeners are required. The whole of the weight of the body can thus be placed in the sheeting, though the increase in strength is such that the weight of the body can be considerably reduced, with consequent saving in hauling and handling.

EXHIBITS AT THE COMMERCIAL MOTOR TRANSPORT EXHIBITION AT OLYMPIA.

(*For Description, see Page* 705.)

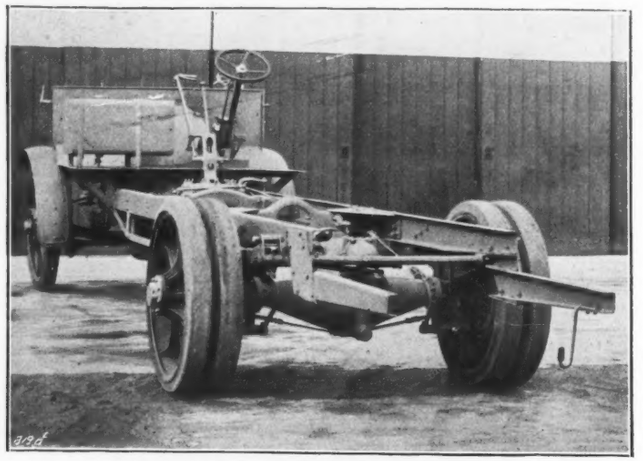


FIG. 73.

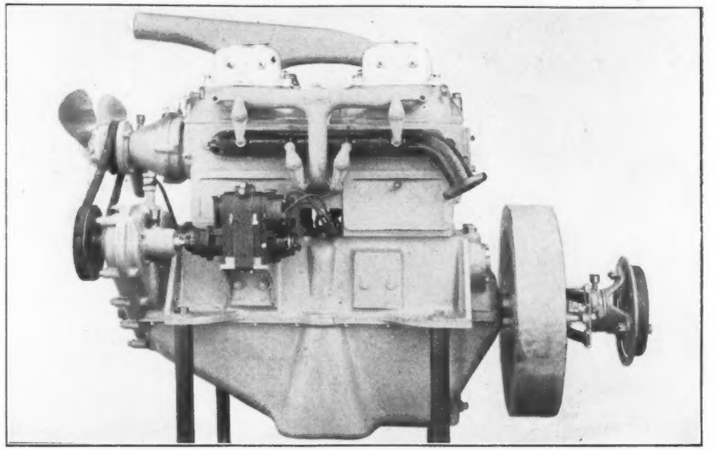


FIG. 75.

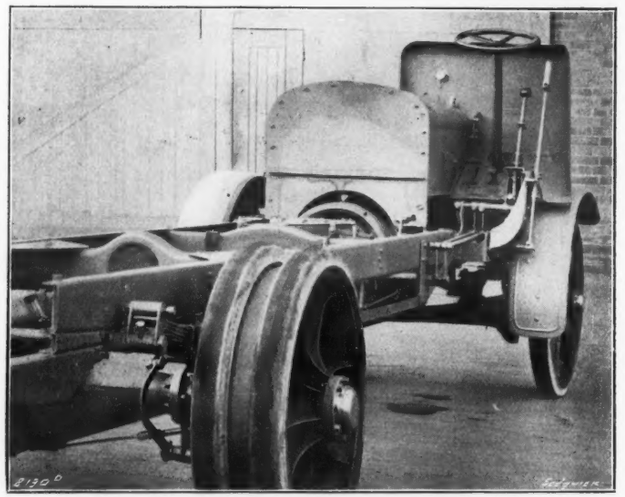


FIG. 74.

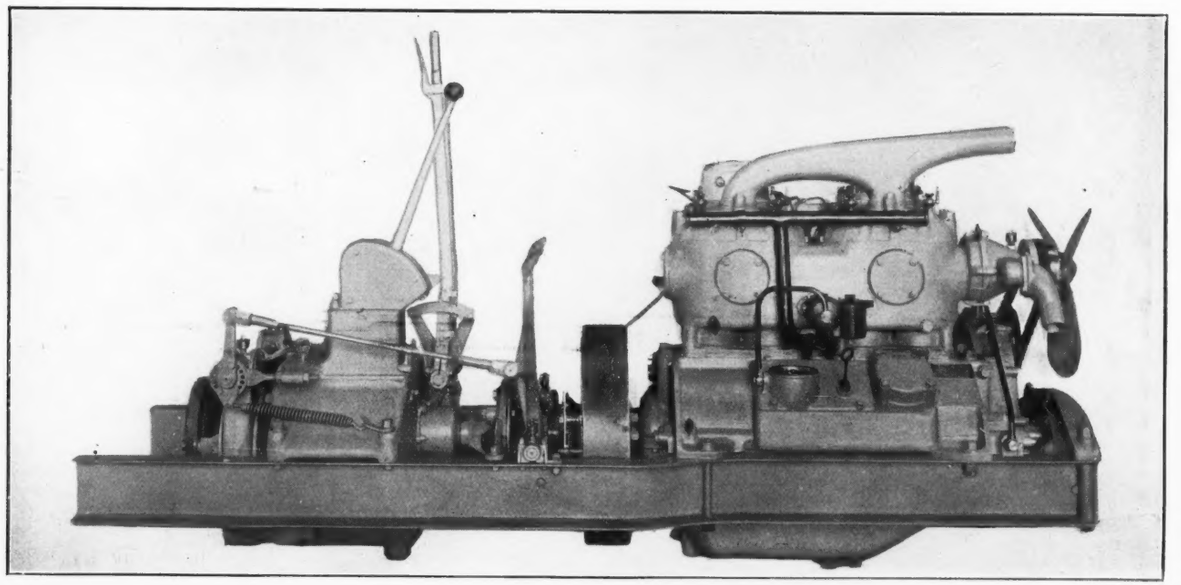
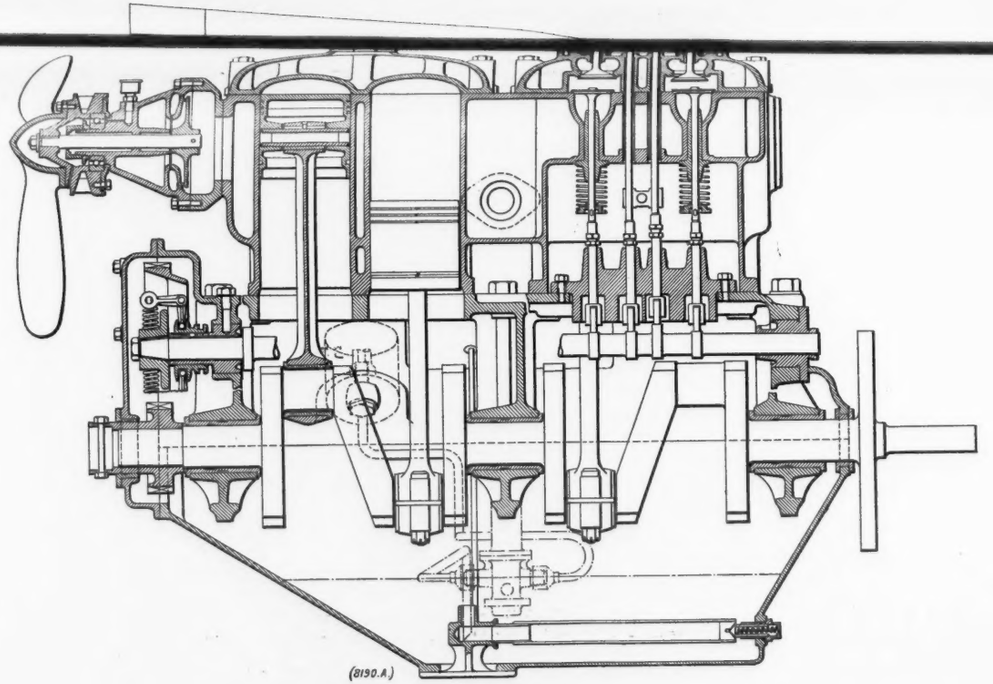
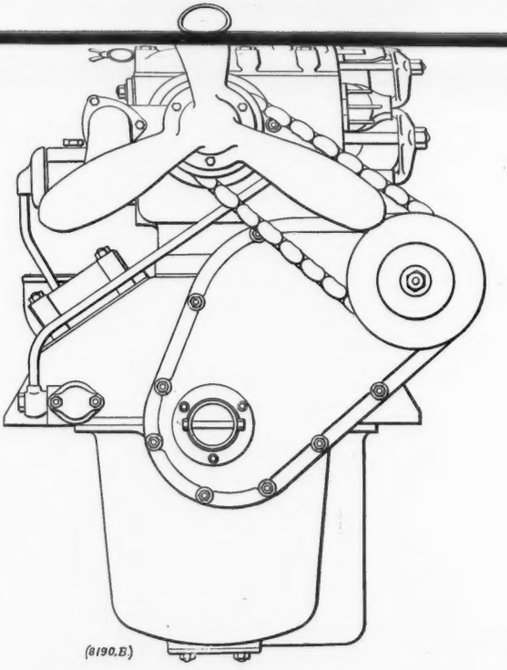


FIG. 76.





Figs. 73 to 78. Chassis and Engine of J Type London Motor Omnibus; Messrs. John I. Thornycroft and Co., Limited, Basingstoke.

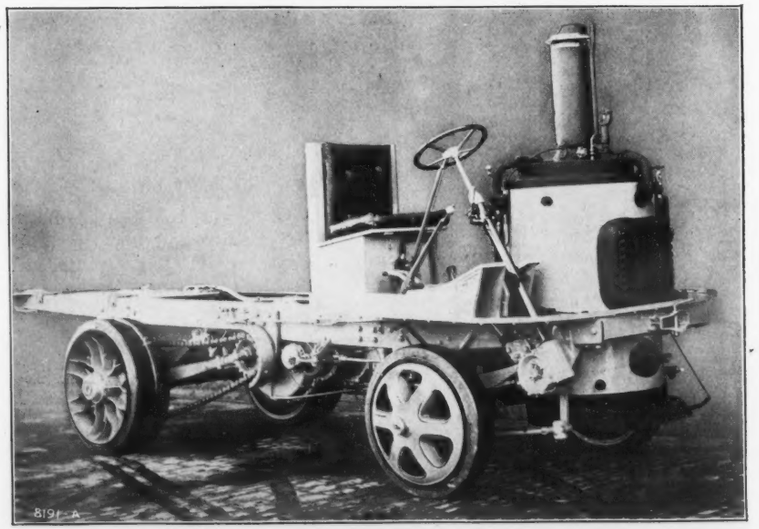


Fig. 79. 6-Ton Undertype Steam Wagon; Messrs. Richard Garrett and Sons, Limited, Leiston.

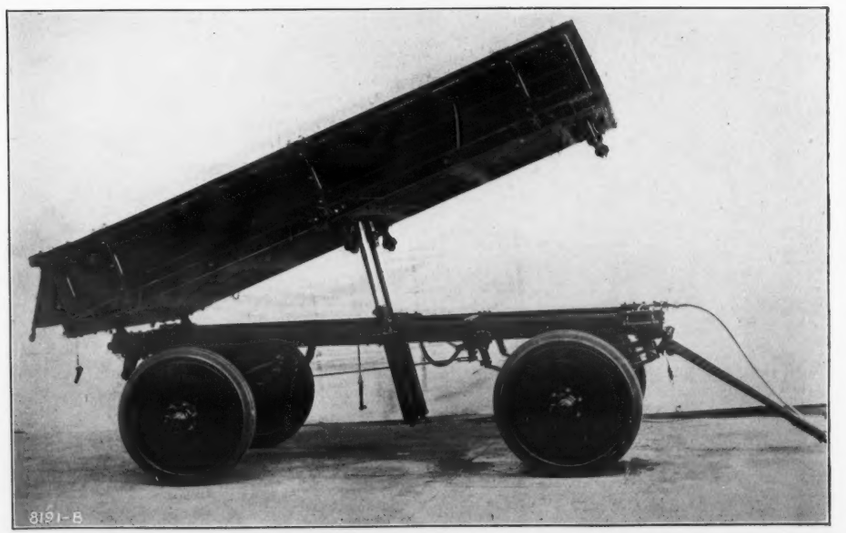


Fig. 80. Tracking Trailer Fitted with Tipping Gear; Messrs. Richard Garrett and Sons, Limited, Leiston.

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Two-Page Plate.—EXHIBITS OF THE COMMERCIAL MOTOR TRANSPORT EXHIBITION AT OLYMPIA.

ENGINEERING.

FRIDAY, DECEMBER 7, 1923.

WASTE HEAT IN POWER PLANTS.

THE discussion on Dr. Mellanby's paper at the Institution of Mechanical Engineers last Friday turned very largely on the question of the recovery of waste heat from internal combustion engines. It was not the primary object of the paper to provoke a discussion on this point, but the subject arose in a natural and almost inevitable way out of the development of the Scott-Still engine. The internal combustion engine has very nearly reached finality, so far as its thermodynamic cycle is concerned. Dr. Mellanby's symposium of oil-engine design on the Clyde is quite sufficient evidence of the fact that there are still widely-divergent views as to the best mechanical embodiment of the internal-combustion principle, even for such a specific purpose as the propulsion of ships, and had he taken a wider survey the evidence would have been even more overwhelming. Nevertheless, in whatever kind of machine the oil develops its power, there is remarkably little difference in the efficiency with which it does its work. Competition between manufacturers indeed is hardly based on the question of fuel consumption at all. Their efforts to increase reliability, and ease of operation, and to reduce first cost and weight being the reasons mainly responsible for the differences in design. We would like to think that mechanical simplicity was also always in the designers' mind, but this is sometimes difficult to believe.

The only internal combustion engine in which a definite attempt to secure a substantially higher fuel efficiency has been made, is the Scott-Still engine, and in this case the inventor did not seek his ends by any modification of the internal-combustion cycle, but sought rather to put to effective use the heat which is usually thrown away. The idea, as everybody knows, is to raise steam in the cylinder jackets from feed water previously heated by exhaust gases, and to use this steam to do work underneath the pistons. The steam can then be passed, if desired, through an exhaust steam turbine, and a further amount of work can be obtained. In order to form a conception of the savings which are theoretically possible by the use of the waste heat from a heavy oil engine, we may refer to the test results of a Ruston engine which we published some time ago. This engine when running at its most economical load turned 35·8 per cent. of the heat in the fuel into useful work at the crankshaft, the remainder of the heat being absorbed in engine friction or going to waste. If we neglect engine friction altogether and assume that the whole of the unused heat could be employed in making steam from water at 60 deg. F., we could get 4 lb. of steam at 250 lb. per square inch for every brake horse-power hour developed by the engine. Expanding this steam adiabatically in a perfect turbine down to 28-in. vacuum, would give us theoretically 0·567 brake horse-power hours. Even on the assumption, therefore, of a frictionless oil engine, a steam boiler working at 100 per cent. efficiency and an ideally-perfect turbine, we should only increase the power obtainable from the fuel by 56 per cent., or alternatively we should reduce the fuel consumption by 36 per cent. In other words, although only 35·8 per cent. of the heat of the fuel was turned into work by the oil engine, less than one-third of the remaining 64·2 per cent. can be recovered even by theoretically perfect apparatus. In practice, of course, we could not hope to effect anything like such a saving as this, since the inevitable losses in the various portions of the plant have to be taken into consideration.

Whether we are considering the efficiency of oil engines, gas engines, or steam engines, we come back to the ultimate fact that only a fraction of the heat of the fuel can be turned into useful work, the rest being necessarily rejected at the lowest temperature of the cycle. The problem of doing something with this rejected heat, therefore, confronts engineers with whatever class of power-plant they are concerned. Even the smallest oil or petrol engines have to have their cooling tanks, fans or radiators, and the amount of low-grade heat which has to be got rid of in large power stations is something enormous. At the new Birmingham Corporation station at Nechells, for example, the generating plant, when complete, will have an aggregate capacity of 105,000 kw. To deal with the waste-heat from this plant, provision is being made to pump 7,000,000 gallons of water per hour through the condensers. The water in its passage will be raised in temperature from 75 deg. to 92 deg. F., thus absorbing a quantity of heat equal to that obtained by the combustion of 5 tons of good coal per hour in a first-class boiler plant. Not only is this heat wasted, but to dispose of it will involve the construction of 41 cooling towers 90 ft. high, through which the water has to be pumped in order to reduce its temperature before recirculation.

If engineers could only dispose of their waste-heat without expense they would bear the loss of it with equanimity, as a tribute laid by Nature on those who operate heat engines. But the trouble and cost of getting rid of it is a serious matter. What is wanted is some use for almost unlimited quantities of hot water. If some chemical or industrial process can be devised which requires low-grade heat, station engineers will gladly supply this in the form of hot water and will gratefully accept the return of the water to them in the coldest possible condition. Could any direct or indirect revenue be obtained from the heat in the circulating water, what is now nothing but a costly and unmitigated nuisance would be turned into a source of profit. We believe that in one of the overseas power stations it was proposed to pass the circulating water through a system of underground pipes with the idea of warming the ground sufficiently to facilitate the culture of vegetables, but whether the scheme was ever carried out, and with what success, we do not know. In another station the whole of the town water supply, amounting to about 5,000,000 gallons per day, was passed through the condensers in the winter. This raised its temperature from freezing point to about 50 deg. F., and enabled the storage basins, mechanical filters, &c., to be operated in all weather without freezing, while it also reduced the number of frozen services in the town. Conditions like this, however, do not obtain in this country.

In discussing the utilisation of waste heat from power stations, mention should be made of those instances where the prime movers are worked non-condensing and the exhaust steam used for heating purposes. This is not uncommon in factories and large buildings such as hotels, infirmaries and other public edifices. The scheme has been carried out on quite a large scale in some instances, and the central portion of the little City of Brandon

in Manitoba, for example, has been heated for years with exhaust steam from the electric light station. The generators in the station are driven by reciprocating steam engines, the exhaust from which is delivered into mains going to the business area of the city. It is a fortunate circumstance that the heavy lighting load naturally occurs during the coldest weather, so that the demands for steam and light approximately coincide, and although the winter temperature is at times far and away below zero, we do not think the losses by condensation in the mains are excessive. It used to be currently reported that the company operating the Brandon plant obtained sufficient revenue from the exhaust steam to pay all expenses of running the station, so that the revenue from lighting was pure profit. In all such cases, it must however be remembered that the station has to have about double the boiler plant, and will burn about twice as much fuel as it would do if equipped with turbines working with a good vacuum.

The outlook for the use of the heat in the circulating water in ordinary power stations does not appear very promising, but there is unquestionably a scope for the utilisation of waste heat in connection with many small power installations. A large number of country houses, schools, infirmaries, &c., now possess their own power-plants, which usually comprise an internal-combustion engine of some kind as prime mover. Hot water is as essential to such establishments as electric light, and if the required quantity of water can be heated by some kind of waste heat boiler attached to their engine, the arrangement will not only be convenient, but will result in considerable economy of fuel. Mr. Clarkson referred to this method of employing waste heat in the discussion on Dr. Mellanby's paper, and described the simple waste-heat boiler which we illustrate elsewhere in this issue. Steam, of course, as well as hot water, can be obtained if desired, and may be used either for the development of power or for heating purposes. We may mention that the two-cycle Beardmore engines described in the appendix to Dr. Mellanby's paper, which furnish the motive power for the Margretian, are working in conjunction with a waste-heat boiler, which it is expected will generate all the steam required at sea from the heat in the exhaust gases of the engines. Although we may expect to see the combination of boilers with internal-combustion engines become a good deal more general in cases where domestic requirements have to be met, as at sea, or in large establishments ashore, such instances afford no useful precedent for large stations whose only function is the production of power. When power production on a large scale is the primary object, whether steam or internal-combustion plant is used, we are still faced with the problem of what to do with immense quantities of low-grade heat, and unless the industrial, or possibly the biological chemists, can provide a commercial solution, there seems nothing for it but to get rid of the heat as cheaply as circumstances permit.

LOUD SPEAKERS FOR WIRELESS.

The crowds of members of the Institution of Electrical Engineers and of the Physical Society, which the discussion on "Loud Speakers for Wireless and other Purposes" drew to the afternoon and evening sessions of the joint meeting, held on November 30, in the Theatre of the Institution, testified to the wide-spread interest of the problem. Radiotelegraphic and telephonic distribution of acoustical vibrations involves many transformations and much apparatus; the meeting was to discuss mainly the last and least satisfactory link of that chain of apparatus, the loud speaker. Dr. Alexander Russell, this year's president of both the societies, was in the chair.

Characterising the practical problem, Dr. A. O. Rankine stated in opening the discussion that we wished to procure at some place a faithful copy of the sounds originated at another place. As long as we were content with feeble intensity, a good telephone receiver applied to the ear fulfilled that condition; distortion came in with large emission. Perfect reproduction, in the physical sense, as distinct from the acoustical, was theoretically impossible owing to the many transformations required. Distortion would affect firstly the amplification of the electric fluctuations, and secondly, the transformation of a portion of the electric energy into sound energy. The third transformation which introduced distortion was the treatment of the aerial vibrations after they had been created. The second tranformations might be done in various ways; but they all involved forced vibrations and since, according to Lamb's dynamical theory of sound, only vibrations of the harmonic type retained their character unchanged in transformations from one system to another, we could not reproduce sounds in general with complete precision.

We resorted to resonance in order to increase loudness. Preferential resonance of the natural frequency of the diaphragm could be suppressed by damping, but at the expense of sensibility. We might raise the natural frequency above the limit of audibility, or we might make it very low. The latter was said to be done successfully in a device of Siemens and Halske, consisting of a strip of thin metal foil suspended between the poles of an electromagnet with its plane parallel to the field; the incoming telephone current was flowing through the foil, the movements of which, of a natural period of 2 seconds, corresponded to that of a diaphragm. The case was different from that of a telephone diaphragm, however, which was actuated by the small variations in the attraction of a strong field arranged for utilising the sensitive part of the magnetisation curve; real sensitiveness and large displacement there seemed to be ruled out, because they might pull the diaphragm into contact with the magnet. With regard to the third point, the treatment of the aerial vibrations redeveloped, the horn should, if possible, be dispensed with, because it might introduce distortion, quite apart from its recognised resonance, by increasing the sound output and not merely redistributing it in a particular direction.

In his paper on "The Theory of Loud-Speaker Design," Mr. L. C. Pocock pointed out that, if V were the impressed voltage of any frequency or amplitude within the region to be amplified without distortion, and P the resulting alternating air pressure outside the system, the conditions were $P = A V$, where A was an efficiency constant independent of frequency and amplitude. Mr. Pocock likened the horn not merely to an acoustical load, added to the receiver, but to a combination of an electric transformer and an electric transmission line, the latter with respect to the propagation of waves across the non-uniform section of the horn, and he showed curves exemplifying the actual pressure variations as measured with two types of receivers. In the first type the moving mass was very light, the flexible diaphragm being driven by a small armature supported on a spring; the second was a loud speaker of the iron-diaphragm type; the second curve showed a steep drop of the pressure between frequencies of 1,000 and 2,000, while the first curve marked that drop at higher frequencies. Mr. Pocock concluded that faithful reproduction could be obtained, but the highest perfection, which might be attained by filters, would necessitate enormous power amplifications, that is, valves of unusually high capacity for operating the receiver.

"The Sources of Distortion in the Amplifier," were discussed by Professor C. L. Fortescue with the aid of many curves, which cannot be explained without reproduction. Ascribing inaccurate reproduction chiefly to curvature of the valve characteristics, the use of intermediate circuits of natural frequencies, the unavoidable reaction effect of most note magnifiers, and the unsatisfactory reproduction in the last (output) transformer, he agreed with Mr. Pocock that valves of considerable power output must be used in the last stage. Yet he did not think that serious distortion could be charged against well-designed amplifiers and circuits; some resonant effects of the transformers could indeed be utilised for compensating defects in other parts of the equipment.

The next paper, on the "Acoustical Problems of the Gramophone," by Mr. H. L. Porter, showed that the simpler problems of the gramophone are not yet by any means all solved. Studying, together with Mr. P. Rothwell, in the first instance, records of simple organ-pipe notes, he found the curves very peaky instead of being smooth, and he soon came to the conclusion that the "sound box" (diaphragm and housing), horn and room conditions should be considered together as a system. When the organ-pipe note peaks had been smoothed down, they tried a pianoforte played by a striker mechanism. Those notes proved very different from the steady pipe notes, and the pianoforte itself upset the recording apparatus behind it; and when finally a good record was obtained, the peculiarities of most reproducing gramophones proved very marked.

Reading his paper on "The Relative Importance of Frequency Ranges in the Audible Spectrum and on Measurements of Loud Speakers," Mr. E. K. Sandeman exhibited curves of audibility and the corresponding energy obtained in pairs by cutting out certain frequencies, with the aid of Campbell filters (consisting of several condensers and inductances in parallel or series). Each point on a curve marked the audibility (or energy) found when all the frequencies below (or above) that point were cut out. The curves of a pair were similar, but of different slopes, indicating that the effect of a certain frequency range on the audibility differs from that on the energy output. The demonstration proved that removal of the frequencies of less than 500 periods did not much impair intelligibility, but made the sounds somewhat unnatural; on cutting out the frequencies above 1,700, commercial speech became impossible, and the elimination of all the frequencies either above or below 1,500 had substantially the same disturbing effect.

The demonstration of "Overtones of the Diaphragm of a Telephone Receiver" of Professors J. T. McGregor-Morris and E. Mallett by means of Chladni figures (sand strewn on the diaphragm) showed that the vibrations of these damped discs may be very complex. Vibrations with a circular node or a diametrical node—the latter inclined to the field—were frequently observed; in the first case the central portion of the disc would vibrate upwards, while the margin moved downward, in the latter case half the diaphragm would vibrate upward and half downward. Judicious balancing of the damping against the resonance was certainly important.

Mr. G. A. Sutherland's paper and curves on "Auditorium Acoustics and the Loud Speaker" were based upon the researches of S. Jäger, of E. A. Eckhardt and of W. C. Sabine. Jäger's exponential formula contains both the surface and the volume of the room; since the two terms do not change at the same rate, large rooms are acoustically not quite similar to small rooms otherwise similar. Curved walls, unless covered, set up subsidiary foci. To deaden the echoes, the walls or their coverings should be porous; our ears are so accustomed to a certain echo effect, however, that complete suppression of all echo sound is not now considered desirable.

But felt walls absorb the higher overtones more than lower overtones, and we have, in speech, moreover, to distinguish syllable and word intelligibility and general phrase intelligibility. When sounds from a loud speaker are rich in high-pitch notes, Mr. Sandeman would have several small rooms rather than one large room; the presence of a large audience would correct the high pitch distortion. As regards musical performances, musical authorities seemed hardly to have expressed definite opinions so far.

The two last papers on the list were limited to demonstrations owing to the late hour. Mr. S. G. Brown was to have spoken on "Some Direction of Improvement in the loud-speaking Telephone," but he only demonstrated his frenophone. Captain P. P. Eckersley spent some minutes in demonstrating his "Gaumont-Lumière Loud Speaker" for moderately large rooms, without describing it at all, though his paper was the only one not printed. The receiver was of large surface, consisting of a disc a foot or more in diameter, apparently made of parchment paper folded up radially in filter fashion.

There was hardly time for a general discussion of the very instructive papers. Dr. W. H. Eccles, the only speaker, emphasised among other things, the wonderful perfection of our ear, which enabled us to recognise a voice in spite of the many transformations and the imperfections of the apparatus.

THE ORGANISATION OF BRITISH RAILWAYS.

IT is a good many years ago since the railways of this country broke away from the system of organisation with which British railway practice was formerly associated. The departmental system served us very well for a long while, but before the war it had been subjected here to a considerable modification. With the grouping subsequent to the passing of the Railways Act of 1920 it was almost certain that the organisation of our lines would have to be altogether recast, and though this is by no means yet completed the future will probably show much greater variety in this country than the past. Under the grouping scheme the several systems have each so far worked out different methods of allotting duties and responsibilities. Whether these will persist or one final type of organisation emerge, it is too early to say. Only one railway out of the four has remained at all faithful to previous British practice, and that even with considerable modification.

The present position was reviewed on Monday last by Mr. C. Travis in a paper read before the Institute of Transport, under the title of "Railways of To-day and To-morrow." It is perhaps a little early for a discussion of the ultimate developments. Mr. Travis reviewed the changes brought about by the war, when the temporary consolidation revealed many directions in which improved operating methods could be employed. The economies, now that the groups are so large, are considerable even if in themselves they appear absurdly small. For instance, ¼*d.* saved per engine mile would mean an economy of 500,000*l.* per annum to the companies. It may be remembered that Mr. Hill, of the Great Eastern Railway, some years ago issued a pamphlet showing the saving to the system if firemen would reduce their coal consumption by one shovelful per mile, but not if loaded with only 2 lb. of coal—the quantity quoted by Mr. Bromley when recently making a serious misrepresentation of the effort demanded of firemen in modern railway service. Such questions of economy, though of immediate import, are hardly germane to the subject Mr. Travis dealt with. This author in his paper considered the departures made by British systems before the war, from the accepted departmental system, citing the reorganisation of the Midland Railway, of the Great Eastern Railway, and the schemes worked by the North Eastern and North British. All these changes from the pure departmental system were adopted to secure better working as regards transportation itself, or some improvement on the commercial side.

Under the grouping scheme, as we have said, only the Great Western retains the departmental plan, but even here there have been some modifications, notably in the direction of making closer the relationship of the chief mechanical engineer and the superintendent of the line. This is one of the crucial matters. The railway exists for transportation, and with the divisional system it is held that the chief of the operating department should, for the most effective working, be in complete control of the motive power. This is not secured in the departmental system; but there are arguments on both sides, and it may be pointed out that on the divisional system a risk arises of the operating official overworking the power and making working, for this reason, more costly. It is hardly necessary to go into the details of a discussion on this old point. The weight of opinion is now undoubtedly to put the whole control of transportation under the operating department, which embraces engineering officials responsible for locomotive running and light repairs. Heavy repairs fall outside this and are attended to by another department. The Southern Railway has thus provided a locomotive running assistant for the chief operating superintendent, and on the London, Midland and Scottish the chief general superintendent also has the direction of locomotive running. The London and North Eastern Railway, on the other hand, retains a chief official in charge of running, in its locomotive running superintendent.

Other changes are in respect of the commercial organisation, but it is difficult to say just what the exact limits and duties in this connection should be, and there is a good deal of diversity of opinion as to whether it should be part of the operating department or independent, and if the latter, exactly where one should stop and the other begin. The chief point is whether the commercial department should manage goods terminals, or merely find the traffic and a good deal of diversity exists at present on this point.

With regard to future operation, Mr. Travis drew attention to the control systems in use in this country, and discussed the possibility of their extension to cover complete railways. It is yet early for much to be done in these matters. In spite of the great upheaval of the past year, the companies have already given us much improved working, but they must be allowed sufficient time to thrash out their schemes in detail. The financial and other matters attendant upon grouping have occupied most of the time up till the present, and it must be many years before the whole executive organisation can be remodelled and unified in each case. It is to be noted that this last summer a total of 146 daily non-stop runs of over 100 miles were in operation in passenger service—a figure exceeding that of any year prior to the war—showing that the companies are intent on providing the facilities which the Act requires.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the Institution of Mechanical Engineers was held at 6 p.m. on Friday last, the 30th ult., at Storey's Gate, Westminster. The chair, in the absence of Sir John Dewrance, was occupied by Mr. W. H. Patchell.

CLYDE MARINE OIL ENGINES.

It will be remembered that at the Summer meeting of the Institution this year, held at Glasgow, Professor A. L. Mellanby read a paper on "Clyde Marine Oil Engines," the discussion on which was adjourned until the Winter Session. We reprinted the paper during the summer (*see* pages 95 and 128 *ante*). At the meeting on Friday last, Professor Mellanby gave an epitome of the paper, drawing attention especially to certain points.

Referring to the necessity that a marine engine should be able to start in any position, this, he pointed out, affected the number of cylinders, which was not, as often supposed, fixed by the power that each cylinder could develop. Starting and manœuvring could not be accomplished effectively with less than six cylinders for the four-stroke cycle and four cylinders for the two-stroke.

With regard to a mean effective pressure, he considered 125 lb. as the maximum obtainable on an ordinary four-stroke cycle, without supercharging. In ordinary sea trials 100 lb. per square inch was usual. In connection with the Burmeister and Wain engine, built by Messrs. Harland and Wolff, he remarked that over 100 ships were fitted with Burmeister and Wain engines, and Messrs. Harland and Wolff had engined more boats with this type of engine than the rest of the firms on the Clyde put together. The six boats engined by that firm between 1915 and 1919 had an aggregate horsepower of 19,200, and six boats engined by them between 1920 and 1922 totalled 30,000 h.p., or over 5,000 h.p. for each ship.

Prof. Mellanby mentioned among the developments which had occurred since the date of his paper, the introduction of the two-cycle Burmeister and Wain engine, the completion of the Scott-Still engine illustrated in our issue of November 23 (p. 639, *ante*), and of the new Beardmore engine. In the latter, an attempt was made to achieve practically the same fuel consumption as in an ordinary Diesel engine, with an engine which was much cheaper in first cost. It was an ordinary two-cycle engine, special attention having been given to lubricating and oil injection methods. The engine in question developed, under normal working conditions, 600 b.h.p. It had six cylinders, the revolutions being at the rate of 300 to 350.

Mr. W. J. Still opened the discussion, and referred to the Scott-Still engine, the latest example of which was illustrated in our columns as stated above, as recently as November 23 (p. 639 *ante*). We need therefore only refer to this matter briefly. Mr. Still pointed out that in this engine, the steam was first used in one cylinder from which it passed to three other low pressure cylinders, giving an expansion ratio of 3 : 1. During expansion the pressure fell from 110 lb. (boiler pressure) to about 20-in. vacuum in the low pressure main. It then passed to a steam turbine, which formed the third stage of expansion. The exhaust finally issued from the turbine to an Edward's air pump with a vacuum of 28 in. The turbine drove a turbo-blower delivering scavenging air to the engine itself, at about 1½ lb.-pressure. From trials, it appeared that the two engines had ample power to drive the scavenging blower, supplying the two engines with scavenge air, entirely from waste heat steam. Also, in passing through the main engine, the waste heat steam provided just about enough indicated power to overcome the engine friction. From Messrs. Scott's own trials he could say that the consumption figure was about 0·35 lb. to 0·36 lb. per horse-power. In a paper read before the North East Coast Institution of Engineers and Shipbuilders in Newcastle, in January last, Messrs. Scott's estimate was given as 0·37 lb. of oil per brake horse-power for all purposes and this had been fairly justified. The use of steam and the absence of compressed air had done much to simplify the auxiliaries. A modern motor installation aboard a ship embraced a main combustion engine or engines, subsidiary internal-combustion engines and electric generators, together with air compressors &c., in addition extensive electric switchboards and wiring; a steam-combustion installation, with steam standbys and winches, and a small lighting set, was certain to prove simpler to construct, to use and to repair. In conclusion Mr. Still showed a number of slides illustrating the early and the more recent Scott-Still engines.

Mr. Thomas Clarkson spoke next, and referred to the recovery of waste heat. It was common knowledge that 25 per cent. to 30 per cent. of the thermal value of the fuel only was converted into work, the greater portion being lost in the cooling water in the cylinders or in the exhaust gases. Mr. Clarkson then proceeded to give particulars of a waste heat installation he had recently developed and tested. This is described and illustrated elsewhere in this issue (*see* page 711), and we may at once pass to the part of Mr. Clarkson's remarks not covered by that article. In the tests Mr. Clarkson referred to, the object was not to make steam, but to supply an abundant quantity of hot water for baths, laundries, central heating, &c., but, incidentally, the figures obtained indicated what was possible in the way of raising steam. The arrangement took the place of a silencer, as well as absorbing a great deal of the heat in the gases. In passing the exhaust gases through the boiler referred to, the starting temperature was 580 deg. F., and 300 deg. F. were dropped in passing through. The inlet temperature of water to the jackets was 54 deg. F., and the rate of flow was regulated in order to ensure that the delivery from the jackets did not exceed 125 deg. F. under ordinary working conditions, so as to prevent the possibility of deposit from bad water. The whole of the water passing through the jackets was then passed through the boiler (which, in this case, was just a water heater), and the temperature went up from 125 deg. F. to between 165 deg. F. and 170 deg. F. In round figures the amount of heat obtained by this apparatus from the exhaust gases was between 50 per cent. and 60 per cent.

He considered that the line of development discussed promised great improvement in the general economy of the combustion engine on board ship. Not only might the required auxiliaries be still operated by steam, but the requirements for heating cabins, for hot water baths, &c., could easily be provided by such an installation. Where it was desired to raise the water to boiling point, the whole of the water discharged from the jacket was not passed through the boiler. By by-passing some of the jacket water a final delivery for the remainder was obtained up to 212 deg. F. There was no difficulty in making steam, as it was quite easy for the boiler to take automatically what water it required from the heated jacket water, in order to maintain a level. It was therefore possible so to arrange matters as to provide a constant supply of steam at any desired

pressure, say, up to 100 lb., and it could be utilised in any way desired, either for driving a turbine, which was, perhaps, the best arrangement with a large installation, or it could be used for the scavenging blowers or for supplementing the main power. It might be said that steam was not wanted out at sea: auxiliaries were only needed in port. He felt, however, in view of the great quantity of heat wasted, that it was worth consideration whether a turbine should not be fitted to utilise as much steam as could be produced from the exhaust of a large Diesel set. At the Fairfield works, recently he had seen a vessel in which four sets of engines, each of 3,500 h.p., were being installed. It was quite possible that one of the sets could be replaced by a turbine, and in that way some 25 per cent. of the fuel consumption might be saved.

Captain H. Riall Sankey remarked that he had had the privilege of testing the earlier single-cylinder engine by Messrs. Scotts, and that French engineers had also tested it. The results obtained by the speaker were very close to those of the French engineers, but, being a single-cylinder engine, there were points that militated against economy. He had estimated those losses, and in this way deduced a figure of 0·353 lb. per brake horse-power at full load. That figure would compare with the figure of 0·356 lb. per brake horse-power given by the makers for the later installation.*

Mr. L. A. Legros made a comparison between the old steam marine trials of 1890–92, under the auspices of the Institution at which he had been present as an observer, and the trials now being conducted of which two had been made, at both of which, on behalf of the Institution, he had watched the proceedings. Mr. Legros referred to the numerous records which were required in connection with the boiler plant and the little knowledge there was at that time with regard to losses. In the case of the present trials of oil engines the oil was measured by two tanks, carefully calibrated, and the fuel was thus more accurately measured than in the case of coal. The steam trials had to run for a long while, on account of the inaccuracies due to the amount of coal actually on the fires from start to finish. In the present case a trial could be made in practically a few minutes, and, plotting the results as they were obtained, anything that went wrong could be at once observed. In the present trials exhaust gas samples were taken under each condition, temperatures were recorded at all sorts of places, and separate measurements made, as, for instance, of the amount going through the jackets, and through the cover and piston. There was a great deal of work to be done, apart from the indicator diagrams. These diagrams were taken both in stroke and out of phase, so that the exact features of the explosion could be traced. With all this the work represented was only part of that required on steam trials. The engine he was considering was tested at four different loads apart from running light. The four loads were run at three sets of revolutions, making 13 trials in all, on the engine of one set. Further, there were the trials with the engines on board. What he had enumerated would, he hoped, convey the idea that the committee of the Institutions of Mechanical Engineers and Naval Architects was doing its work as thoroughly as it was possible to do it. The trials would increase the knowledge as to how power was expended and what wastes in the engine remained to be traced, what was happening in the case of the propeller, and much of interest to the naval architect.

Mr. Daniel Adamson had noted some details which he thought might interest mechanical engineers. With regard to lubrication, the tendency was to overdo this, and oil engines consequently gave trouble through carbonising and the clogging up and breaking of piston rings, &c. The ideal arrangement would be to inject a minute quantity of oil at every stroke, but the lubricators available were not able to control the oil in sufficiently small quantities for this. A satisfactory alternative was afforded by injecting oil at every alternate cycle. Another point was this, the oil should be injected when the piston was at the bottom of the stroke, so that the oil was forced on to the piston and between the piston rings just where it was wanted. The cylinder lubricating oil, representing about one-third of the whole of the lubricating oil used in the engine, ran from 2 gallons to 6 gallons a day of 24 hours with a 3,600 h.p. engine, varying from 1½ pint to ½ gallon per cylinder per day of 24 hours. That showed considerable variation of idea as to the amount of lubricant required.

The upper edge of the piston rings should be rounded off. The clearances of the rings were important, and the end clearance should permit of the expansion of the piston ring when at work. The piston rings should be kept well below the top of the hotter end of the piston. In the case of the Sulzer engine shown, the piston rings were close up to the end of the piston, whereas in the other cases the rings were some distance from the working face of the piston, the proper arrangement. Most of these points would be found to be considered in a paper, by Mr. J. Lamb, read before the Institution of Marine Engineers in March of this year on "The Operation of Marine Oil Engines." As a boiler-maker he doubted the wisdom in the Scott-Still engine of the cast-iron boiler with the cast-iron fire box hooped with steel hoops, as described. Again, in the Scott-Still engine, why should a water-tube boiler be employed. The flame tube boiler, in which the heating medium was inside the tube and the water outside, would be more compact and efficient. Dr. Mellanby had carried out experiments and had obtained very valuable information, with the result that what was called the exhaust heat boiler became merely an exhaust pipe with a water jacket round it—an almost unnoticeable part of the equipment, yet taking up all the heat available in the exhaust gases.

Mr. W. A. Tookey referred to Fig. 2 in the paper, showing percentage of oxygen in the exhaust gases in relation to mean effective pressure developed in the cylinders. That, he thought, confirmed the fact that mixtures much stronger than about 42 B.Th.U. per cubic foot could not be burnt in Diesel engine cylinders. He had made rough calculations, which made it clear that with a mixture of higher strength the efficiency fell. On the question of the thermal efficiency of the internal-combustion engine of Mr. Still's apparatus the consumption was cut down to about 0·35 lb. of fuel per brake horse-power, by recovery, so to speak, of the friction losses of the engine. He had made tests of a solid injection engine, of the Ruston type, which resulted in a figure of about 0·386 lb. of fuel. These tests confirmed the low figures reached in present practice. The engine was small, not much exceeding 100 h.p.

The chairman said, referring to Mr. Clarkson's application of the waste heat boiler, that many engineers had tried to put such a boiler behind an internal-combustion engine, but had not been able to find space anywhere near the engine for a normal size boiler. There was hope, however, if the size of the waste heat boiler could be reduced to the dimensions of Mr. Clarkson's boiler. He believed we were making greater progress with the Diesel engine in this country than America, but it was also being adopted over there.

Professor Mellanby, in reply to the discussion, said Mr. Clarkson was to be congratulated on achieving, with his special heater, a reasonable size of waste-heat absorber. He would ask if Mr. Clarkson had found out what the actual temperature of the exhaust gases was by calculating the heat put into the water? In endeavouring to solve the waste heat problem, he had been interested to find that, with ordinary single cylinder internal-combustion engines, the exhaust gas temperature, measured with any type of thermometer—mercury, thermo-couple or resistance—bore no resemblance to the actual temperature which the gases must have had. It was possible to speak confidently on the fact that the actual temperature must be much higher than the thermometer recorded, since no one would believe it possible to get more heat into water than the gas was able to give it. Heaters were only of large size because engineers refused to believe in scientific tests carried out many years ago. The rate of heat transmission depended on the rate at which the gases flowed over the surfaces. He had been able to get out a design for a waste heat absorber which could be put into the exhaust pipe of a 35 h.p. Diesel engine. That engine had a 4-in. exhaust pipe, which was taken out and replaced by a 3-in. pipe. The 3-in. exhaust pipe was then filled up with three tubes of 1-in. diameter. The gases rushed through the diminished space at a very high rate. The amount of heat put into the water or extracted from the gas, was almost exactly as predicted from simpler and smaller trials carried out under ordinary conditions. Mr. Clarkson had shown practically the same thing, *i.e.*, if the gases were forced through at high speed there was no need for a large waste heat absorber. Small arrangements could be got which would not be seen by anyone who had not been told that there was a waste heat boiler on the engine.

He had given the oxygen curve referred to by Mr. Tookey, because he felt that by taking exhaust gas analyses under proper conditions a better idea of volumetric efficiency was afforded than could be obtained in any other way. Instead of putting in special measuring apparatus such as anemometers, &c., used in laboratories for measuring the air taken into the engine, more reliable information was obtainable from good exhaust gas analyses. It was necessary to recognise that the Diesel engine was now absolutely reliable. Recently the engineer of a Diesel engine ship could not speak in high enough terms of the engines during his last voyage from Spain, stating that he had never had a more uncomfortable time in his life so far as weather was concerned. The engines were practically flooded with water the whole time. Yet they went round minute after minute, whereas another boat (with steam engines) that put out from Gibraltar at the same time arrived at Liverpool four days later.

The chairman then proposed a vote of thanks to the author, which was passed with acclamation. Announcements were made as follows: An informal meeting would be held on Friday, December 7, at 7 p.m., the subject for discussion being Two-cycle *versus* Four-cycle Internal-Combustion Engines, introduced by Mr. Ashworth Wans. The annual dinner of the Institution would take place on Thursday, December 13. The next general meeting would be on Friday December 14, when the paper to be discussed would be "Exhaust Valve and Cylinder Head Temperatures in High-Speed Petrol Engines," by Professor A. H. Gibson, and H. Baker Wright. The proceedings then terminated.

* See page 640 *ante*.

NOTES.

The Panama Canal.

The report of the Panama Canal for 1923 shows to what an increasing extent advantage is being taken of this new means of communication. The figures for tonnage are rapidly approaching those of the Suez Canal, which during the year 1922 passed shipping representing 21,360,000 tons, compared with 18,605,786 tons for the Panama Canal for the year 1922-23. The tonnage thus reported for the latter compares with 11,417,459 tons in the previous year, the growth having been largely accounted for by the expansion of the Californian oilfields. The number of vessels making the passage of the Canal in the twelve months was, 3,967, including 121 motor ships. Vessels are worked through the Canal on a regular schedule. The greatest number of vessels passed through Gatun locks in a day was 24 commercial sea-going vessels put through in 23 lockages. This was accomplished on May 25, 1923. Actually 38 vessels have been passed through on one occasion, but these included submarines and destroyers in groups. The average number of lockages per diem has worked out at Gatun at 11·7. At these locks there were only nine delays of more than 10 minutes' duration, due to faulty operation or failure of equipment, the total time aggregating 5 hours and 4 minutes. At the other locks delays were of a trifling character. With regard to water supply, this proved ample during the year for all lockages, and for operating the hydro-electric plant at Gatun continuously, the steam plant at Miraflores being held in reserve. Surveys continued in the Chagres Valley with a view to locating a site for a dam above Alhajuela to provide the additional storage which will become necessary. A number of small slides occurred during the year, and the total amount removed from the East and West Culebra Slides in the year was 1,290,250 cubic yards. At

East Culebra, in December, 1922, about 595,000 cubic yards of material moved into the basin excavated at the side of the canal, and about 150,000 cubic yards moved into the canal itself. The slides caused no interruption to traffic except for one day to a vessel drawing 34 ft. of water.

SURFACE HARDENING OF IRON BY NITROGENATION.

When nitrogen is bubbled through fused electrolytic iron, the metal does not take up more than 0·04 per cent. of nitrogen at ordinary pressure and only 0·3 per cent. at a pressure of 200 atmospheres. More nitrogen is chemically bound when ammonia is passed over finely-divided iron at about 650 deg. C.; the nitride Fe_2N, with 11·1 per cent. of nitrogen, is then formed. When pieces of iron are used in this process, they become covered with a hard, brittle crust of nitride, in which, according to A. Fry, of the Friedrich Krupp A. G.; Essen (*Stahl und Eisen*, October 4), two layers may be distinguished, the outer consisting essentially of the long-recognised nitride Fe_2N, the other of the new nitride Fe_4N with 5·9 per cent. of nitrogen. Heating the nitride Fe_2N in a vacuum Fry observed that it began to decompose at 440 deg. C.; the decomposition stopped as the temperature was raised, at 550 deg., but set in again at 560 deg. C. and once more, though to a much smaller extent, at 630 deg. Magnetometer tests further support the view that there are two (possibly more) nitrides of different thermal stability. The nitride Fe_2N is not magnetic below 440 deg. C., it then passes into the nitride Fe_4N which becomes magnetic when cooled down to 480 deg.; above 630 deg. the iron contains only 0·5 per cent. of nitrogen, probably in solid solution, and is again magnetic. Similar characteristic points, observed in iron and steel by Kido and by Sawyer, had been interpreted in other ways. A technically interesting feature is that the surface layer of nitride is hard and can be made still harder by alloying the iron—or also steel, containing up to 0·6 per cent. of carbon—in the experiment described, with metals which incline to nitride formation, such, for instance, as chromium, titanium and aluminium. Hardly any increase in hardness was obtained by adding nickel or cobalt to the steel. By alloying the steel with about 3 per cent. of aluminium or chromium, the surface hardness was raised by 300 per cent. and more. The piece may be finished before being hardened with nitrogen; the piece is not distorted by the treatment, the volume being only very slightly increased. Unfortunately the depth to which the hardening penetrates amounts to only 0·7 mm., and the crust is very brittle. Yet Fry speaks of hardening bearings, parts of small machines working at high speeds, instruments and even toothed wheels by this treatment.

LITERATURE.

American Petroleum Refining. By H. S. BELL, C.E., Member of American Petroleum Institute. Illustrated. London: Constable and Co. [Price 24s.]

THIS eminently practical work on the technology of petroleum refinement must necessarily appeal more to American readers, with whom the industry has attained huge dimensions, than to ourselves, whose activities being limited by the want of raw material, are compelled to survey the operation from the position of spectators. Now and again we hear of some fresh development, such as the establishment of a refinery at Llandarcy, Swansea, where with the assistance and supplies from the Anglo-Persian Oil Company a sound industrial concern is growing up, which we may well hope may have imitators, but so long as the United States and Mexico are capable of producing the main proportion of the world's demand, we must be content to be dependent on those countries for the bulk of our petroleum products. Mr. Bell is discussing the procedure of refineries that have a daily capacity of 10,000 barrels or more, and his introductory chapter makes evident how hopeless any thought of competition would be with the United States, where during the last half-century has been built up an industry that is now producing 400,000,000 barrels a year, possessing a value in excess of that of any other mineral. To handle this enormous production, there are in operation or under construction, 472 refineries fed by 50,000 miles of pipe line and 70,000 tank cars, while the tonnage of vessels on the high seas engaged in the transportation of petroleum and its products exceeds 5,000,000 tons.

Seeing how rapidly this industry has grown, and witnessing every day some new application that still further increases consumption, one cannot help asking how long the stores accumulated through geologic time will furnish the annual demand, and prevent the world being faced by the depletion of this great national asset. The author is not called upon to discuss this side of the problem in any great detail, but his rapid glance, though confined to immediate necessities, is hardly reassuring. He points out that production has always been equal to demand, and that at the present time production is so much in excess of consumption that a sharp fall in the price of crude oil is in evidence. Following the decision of some recent authorities, he places the underground reserve at 6,500,000,000 barrels, but this estimate can be little more than a guess, since direct examination is difficult, if not impossible. It is admitted, however, that the Appalachian field, the first to be developed in the United States, and which has acquired a well-deserved reputation for its high grade lubricants, has long since passed its prime. Against this diminishing source he places the huge supplies from Oklahoma and Kansas, and maintains a hopeful outlook. At the same time, he insists that the warnings of competent geologists should be regarded, and urges the necessity of increased efficiency in refining, and of the introduction of mechanical improvements in the apparatus operated by petroleum products as fuels. This, of course, is mere prudence, and no hint is given of the gravity of the economic situation, which will inevitably have to be faced. Oil fuel and allied products are being squandered in a manner as criminal as it is incomprehensible in face of a wasting asset, but little or no effort seems to be made to control the destinies or regulate the output of oil lands and their contents.

Two chapters are contributed by Messrs. Gray and Drogin on the chemical and physical characteristics of petroleum. These are instructive and precise, containing what is necessary for the better understanding of the general processes followed, and the authors wisely forbear from entering into those interminable controversies on the origin, or on the mechanism of formation of petroleum, with which so many writers think it necessary to adorn their treatises on practical matters. Speculation is interesting, but Mr. Bell, daily occupied with the exacting details of mechanical and commercial requirements, disregards its allurements, preferring facts to theories. His stern adherence to manufacturing processes and the duties of management, so far from robbing his book of interest, makes a greater claim on our attention. He introduces us to a type of strenuous industry that can be studied from a position of detachment and directness, the clear descriptions enabling us to follow the manifold operations to which the various classes of crudes are successively submitted, till the final product is secured.

The general purpose and method are easily apprehended, it is only the details that may become bewildering. Experience and ingenuity have introduced many devices that accelerate production and improve the result. Of these, many remain the secret and the property of the several firms that originated them. Mr. Bell discreetly makes no effort to penetrate these secret, or semi-secret processes, and refrains from attempting the description of any apparatus or methods that have not been adopted in practice by at least two independent companies. Nevertheless he has a wonderful tale to unfold, owing mainly to the magnitude of the operations involved. We are invited to watch the process of distillation carried on in giant stills that have a capacity of 1,200 barrels, and perhaps of even greater content, though the necessity for handling such huge masses is growing less, owing to the introduction of methods of continuous distillation, and especially through the use of the tube or pipe still, that is challenging older apparatus by reason of its low cost and high efficiency. By exact description assisted by well-arranged diagrams, we can follow the processes adapted to the separation of the various distillates, the "cuts," successively differentiated by the gravity of the "steam," and learn how crude naphtha gives place to kerosene distillate and crude kerosene, to be followed in their turn, by fuel oil and wax distillate, this last containing many compounds of the solid paraffin series, and the valuable neutral oils from which high-grade lubricants are prepared. Or if the crude oils contain much asphalt, we are led to examine the process of "cracking" or the decomposition by heat, a treatment by which the hydrocarbon molecules, thus rendered unstable, break down, forming simple molecules of lower boiling-point, and giving a maximum yield of valuable light products.

These preliminary results are, however, only the beginning of the tale. They put us in possession of the rough elements of the industry. Gasolines and naphthas have to be appropriately treated to remove objectionable colour, usually by filtering through bauxite, or by passing the vapour of the oil over heated bauxite. From kerosenes, sulphur and unsaturated hydrocarbons have to be removed, these latter proving detrimental to the production of a good lubricant, since they are liable to deposit free carbon. Wax, when present, is in an amorphous state, and has to be reduced to crystalline form by special treatment in a wax plant. Filtering, cold settling, compounding, storing, all need careful attention, and the author describes the various types of apparatus that facilitate each process, pointing out alternative methods of working according to the character and quality of the crude, supplying in fact a mass of information, that will be valuable to the owner and engineer who, accustomed to local methods of working have not availed themselves of the varied experience collected at other centres.

Not the least interesting chapter to the English reader is that on bulk transportation, for our enterprise has led the way in the construction of tank steamers, which have now acquired such dimensions that only a few ports can accommodate the largest vessels when fully laden. The average transatlantic tanker carries about 3,000,000 gallons of oil. The dimensions that give the most economical results are 420 ft. long, 55 ft. beam, and 26 ft. draught, but these are much exceeded by vessels operating between definite points of shipment and discharge, where they can be accommodated in deep water harbours. The majority are still equipped with quadruple reciprocating steam engines and Scotch boilers with superheaters, although such craft are peculiarly fitted for internal-combustion engines of various design. Geared turbines have been fitted to recently constructed tankers, and all burn liquid fuel. The pumping arrangements, capable of discharging 1,200 barrels to 2,000 barrels an hour, have frequently to be designed, so that two or more grades can be pumped out at the same time. In a 10,000-ton ship, carrying several grades of oil, it is usual to have two pump rooms with six pumps in each room, provided with separate suctions and discharges connected by distinct hose to the dock. All oil tankers suffer from the disadvantage that they must return to the post of loading in ballast. All attempts to carry other cargoes than oil have proved unprofitable, and consequently the carrying trade is not so remunerative as the public imagine.

It is impossible to read the clear exposition given by the author, without realising how greatly the industry has benefited by an alliance with science. Chemistry has broadened the knowledge of the constitution of the hydro-carbons, though the nature of the reactions that take place in the "cracking" process still remains unexplained. The theory of colloids has been invoked to explain the problem of underground migration: Geology has taught where new fields may be explored, and diminished the necessity for "wild-cat" drilling, while engineering has discovered improved methods of constructing machinery of vast dimensions and has thus facilitated the refinement of crude oils, cheapened processes, and made the product available in many branches of industry.

The Road. By HILAIRE BELLOC. Printed and Published for the British Reinforced Concrete Engineering Company, Limited. Charles W. Hobson, St. James'-square, Manchester.

WE have been accustomed to Mr. Belloc in the light vein of the pleasant essayist, amusing, if flippant,

and insistent, if banal. Here we meet him on more serious ground, for while lightly discussing how roads grew and disappeared with the need that created them, meeting more or less imperfectly the demands of transport, he sketches a scheme that shall relieve vehicular traffic of the difficulties by which it is beset and make locomotion easy and efficient. Naturally one would not suspect Mr. Belloc of having any expert knowledge of road construction, around which he writes with so charming an airiness. Harold Skimpole could not be more irresponsible. Unfettered by financial considerations, the sordid necessities of providing the means give him no anxiety, and unhampered by mechanical and technical difficulties, he can give ample scope to a particularly vivid imagination. For him is the task of suggesting lines of thought "which if they lead to practice need a detailed science that I do not possess."

We are afraid Mr. Hilaire Belloc is too modest. He can give to those lines of thought a picturesque aspect and a seductive lure, that would almost persuade us to part with what is useful and necessary to be replaced by what is charming and graceful. His is the art of the wizard. He would persuade us, nay, he convinces us, that no small portion of our trouble arises from the fact that English genius has produced and utilised the locomotive and the railway, an innovation that has had two deplorable effects upon the economic life of England. First, it killed the canals, and secondly, it killed all the schemes for ordering, straightening, and building the national road system. When Parnell and Telford had devised a scheme whereby all the great centres of English industry might have been connected by broad, straight roads with excellent surface, this pernicious system of iron lines spread itself over the face of the country, and perpetuated all the evils latent in the narrow winding roads, impressing on London that system of "bottle-necked" exits which strangle its traffic at the origin. A truly lamentable result, and it is only when far from the glamour of the author's persuasive arts and the fascination he exerts, that we begin to ask ourselves what kind of surface it would be necessary to give to those roads, that carried by horse traction the weights that the locomotive distributes at distances remote from the source of origin, and how many horses and drivers would be requisite to take charge of the intolerable load. Congestion seems written large over the whole scheme, from which Macadam, the inventor of the water-bound road, could not have extricated us. But we should be unwilling to hint to the able author that the locomotive and its accessories have not been without their compensations, for he sees in the railways the embodiment of the individualist and aristocratic system, "which, however much it has increased trade and commerce has sacrificed the interests of the community to a comparatively small wealthy class, while the mass of Englishmen became, and have remained, impoverished."

Mr. Belloc's scheme is easily outlined, for he has not burdened it with details. The street traffic of the towns, whose amount is an immediate and pressing problem facing the citizens of London, is left severely alone, and the scheme narrows down to the provision of great arterial roads, very broad and very straight, with a specially constructed surface on which only motor traffic would be allowed to run. These arterial roads are not to penetrate the towns towards which they approach, but to make a circuitous route that would at once avoid the congested traffic, and act as a conduit in drawing off the excess. There is no intention of disusing existing roads, but it is anticipated that it would be such an advantage for long distance traffic to use the great roads, that at the expenditure of greater mileage "you would find the new traffic seeking them at the nearest point upon one side, and clinging to them for as long as possible." An example is given, but the benefit conferred is not very convincing, and we submit that if a straight road existed from London to Birmingham, and another from London to York, the advantage either would present to the man who wanted to travel from Leicester to Derby would be insignificant.

On the one point of raising funds, whether for construction or maintenance, we can heartily endorse the author's opinion. A simple method of taxation is necessary, and should be based on the factor that most nearly represents the use of the road. This factor is fuel. To tax fuel may entail some injustice and some anomalies, but probably less than any other. The present complicated method, whether founded on weight, or on power, is injudicious: it leads to the production of cars that are not the best adapted to the purposes to which they are put, but on which the tax is lightest. A fuel tax is easily collected. It can be imposed at source and in bulk, is paid gradually and at will, and yet paid inevitably.

It would be doing an injustice to an eminent writer if we allowed it to be supposed that the object of the book is mainly utilitarian. In various previous works Mr. Belloc has delighted us by recalling the human side of road history and developing its hidden romance, a subject that he has made peculiarly his own. On this subject he writes *con amore*, and whether we agree with his conclusions or not, we feel that we are listening to one who has travelled over the road, mastered its many details, and is ready with all the information that can be extracted from it. He shows how the features of topography and soil have influenced or modified the choice of direction, the obstacles that have to be avoided or surmounted, and the consequences that have followed the adoption of either plan. Time is as important a factor as situation, and the change worked by social and political influences is made to produce a picturesque background, that the author skilfully uses in presenting this interesting chapter of English history. Even the turnpike system which it may be imagined is treated with little respect, is made to contribute an instructive chapter in this entertaining review.

The one lesson we learn from this passing panorama is that each generation strove to produce the road and the means of transport that sufficed for its needs, and made no attempt to determine what was most fitting for the future. With all due respect to Mr. Belloc, we submit that our ancestors were justified. It is difficult, perhaps, impossible, to imagine that which is outside our experience, and by no exercise of thought can we forecast what will be the demands or the necessities of the next century. The author's view is apparently limited by the motor car, controlled by an internal-combustion engine, and what will minister to its convenience and usefulness. But this mode of locomotion will pass as the canals have passed, and it may be that aviation will take the place of road traction, and open spaces to accommodate the arrival and departure of aeroplanes will appeal to the next generation, a mode of locomotion rendering lanes and arteries alike of equally small importance.

Engineering Kinematics. By William Griswold Smith, M.E., Associate Professor of Mechanical Drawing, College of Engineering, North-Western University. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

Complaint has often been made that the training provided for engineers, entering the profession is inadequate and unsuitable, and that the consequence of this education is that men adopt the easy path of following the course that has been uniformly pursued, attempting no original work. The remedy, it has been suggested, is to be found in systematic university training, and that the only means of securing a supply of properly equipped engineers, capable of advancing the science and upholding a high standard, is to be found in greater attention to science. The gradual and necessary substitution of automatic machinery and control, owing to the increased expense of production brought about by the demands of labour, makes the need of competent leaders acutely felt, for the elimination of mere mechanical operation is bringing about a revolution in the routine work of the shop. The publication, from many sources, of works on kinematics, the Theory of Machines, and the like, emphasises the demand for greater competency, and the use of such books should go a great way towards qualifying those to whom the advantages of a full university curriculum are denied.

The author's intention is to create a greater interest in the art of mechanical design as applied to the transmission of power. The work of the prime mover, assumed to be material, and not derived from gravity or electricity, is taken for granted, kinematics, as here understood, continuing the work of transportation or modification from that point. Linkwork, that most fascinating field to the designer of machinery: Direct contact pairs, which include friction wheels, cones, and other device working on two shafts without an intermediate belt; toothed gearings, whose improvements have exercised the skill of the mathematician and the ingenuity of the mechanic; these forms and many others are all in turn made to furnish applications of the principles of design. Accuracy, mechanical efficiency and economy of productive work are everywhere kept in the foreground, and the book being eminently practical, the examples, which are made a strong feature, are selected with a view of increasing interest in engineering practice. The author in making the selection has drawn largely on the facts collected in technical journals, trade catalogues, and miscellaneous magazine articles. He contends that industrial literature is of outstanding importance to the engineer, because he is brought into contact with the accumulated experience of specialists. This may be an obvious truism, and one often overlooked, but certainly Professor Smith has used his material wisely and well, securing a freshness that is unusual and a closeness of connection between the principle under consideration and the illustrative example, that other teachers will welcome.

As a typical example of the manner in which well-known principles are applied, reference may be made to the treatment of rolling ellipses, a subject on which the author is inclined to specialise. It has been said that if mathematicians had studied elliptical functions with the care and thoroughness that has been devoted to circular functions, mathematics would have been in a much more advanced state, and the author indicates that the neglect of elliptical gearing has operated adversely on mechanical development. Two equal ellipses mounted on their respective foci, at a distance equal to the major axis, possess all the conditions of pure rolling. This is an elementary proposition capable of various developments in practice, but a simple analysis would show that the intelligent employment of the underlying idea would furnish great variety in velocity ratios, quick return, high maximum speed and in sudden impact that can be utilised for delivering effective heavy blows. The development of full possibilities has not been encouraged, because the repetition of familiar devices is easier than the introduction of novelties. Therefore, practical objections have been raised to its general employment by inventing objections, which the author exposes. It has been urged as a drawback, that the ordinary arrangement provides a positive drive for only half a revolution, and further that elliptical gears are difficult to construct and expensive to manufacture. It is true, that each tooth in a quadrant must be different in outline owing to the changing radius of curvature of the pitch line. In the case of cast gears, where a pattern has once been made, this objection disappears.

In various ways the history of kinematics shows that progress has followed the efforts stimulated by a desire to overcome difficulties, and wider opportunities may well lie before the application of elliptical gearing. The improvements in helical bevel gear, improvements both in the design and in the material, have been the result of many years of study, and the object of Professor Smith is apparently to encourage his pupils to break new ground rather than to be content to tread in the footsteps of their predecessors. Suggestion and theory must always proceed commercial production, and it is not to be supposed that the work of many brains has exhausted the possibility of new design. We have in this volume a very comprehensive description of the cycloid and the involute as applied to gear outlines, perhaps the only curves that have been deliberately selected for this purpose, but there is no reason to think that there are no others that would prove equally serviceable.

Perhaps enough has been said to show that suggestion and incitement to progress form the keynote to this elementary treatise. Although it may be urged that kinematics as a science may be satisfied by a correct outline, indicating working conditions, and therein differs from the science of machine design, the author has always kept the necessity for application in view, and it seems to us

that he has been wise in taking the broader view of the requirements of engineering data, or at least of keeping them in mind. His book will be useful to those who prefer either view point.

BOOKS RECEIVED.

The Inspection and Testing of Materials, Apparatus and Lines. By F. L. HENLEY, M.I.E.E. London: Longmans, Green and Co. [Price 21*s.* net.]

L'Industrie du Gaz. Vol. I. *Distillation de la Houille.* Vol. II. *Traitement des Produits et Sous-Produits de la Distillation de la Houille.* By RENÉ MASSE and AUGUSTE BARIL. Paris: Masson and Cie and Gauthier Villars et Cie. [Price 20 francs each.]

The Engineer's Draughtsman. By H. VARLEY. London: George Routledge and Sons, Limited. [Price 5*s.* net.]

Practical Moulding. By S. JONES PARSONS. London: George Routledge and Sons, Limited. [Price 5*s.* net.]

Coal Handling at Ports. A Survey of the Various Systems in Vogue, with a Consideration of Their Respective Merits. By BRYSSON CUNNINGHAM, D.Sc., B.E., M.Inst.C.E. London: Chapman and Hall, Limited. [Price 13*s.* 6*d.* net.]

Die Berechnung des Werkstoffverbrauches bie Gestanzten gezogenen und gedrehten Gegenstanden im Bereich der Metallindustrie. By LEONHARD GLUCK. Berlin: Julius Springer. [Price 0·70 dols.]

Forschungsarbeiten auf dem Gebeite des Ingenieurwesens. No. 264. *Der Warmeübergang in der Vebrennungskraftmaschine.* By Professor Dr. Ing. NUSSELT. Berlin: Verlag des Vereines deutscher Ingenieure. [Price 3*s.* 6*d.*]

United States Geological Survey. Mineral Resources of the United States. I: 3. *Bismuth, Selenium and Tellurium in* 1922. By V. C. HEIKES. I: 4. *Lead in* 1922. *General Report.* By C. E. SIEBENTHAL and A. STOLL. I: 5. *Zinc in* 1922. By C. E. SIEBENTHAL and A. STOLL. I: 7. *Lead and Zinc Pigments and Salts in* 1922. By C. E. SIEBENTHAL and A. STOLL. II: 3. *Asphalt and Related Bitumens in* 1922. By K. W. COTTRELL. Washington: Government Printing Office.

Strength of Materials. By WALTER E. WINES. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 11*s.* 3*d.* net.]

United States Geological Survey. Bulletin No. 744. *The Lime Belt of Massachusetts and Parts of Eastern New York and Western Connecticut.* By T. NELSON DALE. [Price 30 cents.] No. 751—B. *Progress Report on a Subsurface Study of the Pershing Oil and Gas Field, Osage County, Oklahoma.* By W. W. RUBEY. Washington: Government Printing Office.

United States Geological Survey. Water Supply Paper No. 501. *Surface Water Supply of the United States* 1919–20. Part I. *North Atlantic Slope Drainage Basin.* [Price 30 cents.] No. 510. 1919–20. *The Great Basin.* [Price 30 cents.] No. 512. 1919–20. Part XII. *North Pacific Slope Drainage Basins.* (A) *Pacific Basins in Washington and Upper Columbia River Basin.* [Price 25 cents.] NATHAN C. GROVER, Chief Hydraulic Engineer. Washington: Government Printing office.

Materials and Their Application to Engineering Design. By E. A. ALLCUT, M.Sc., and E. MILLER. London: Charles Griffin and Co., Limited. [Price 32*s.* net.]

Coal Tar Distillation and Working Up of Tar Products. By ARTHUR R. WARNES. Third edition, re-written and greatly enlarged. London: Ernest Benn, Limited. [Price 45*s.* net.]

Coke and Its Uses: In Relation to Smoke Prevention and Fuel Economy. By E. W. L. NICOL. London: Ernest Benn, Limited. [Price 19*s.* 6*d.* net.]

Mechanical Road Transport. By CHARLES GUTHRIE CONRADI, M.I.Mech.E. London: Macdonald and Evans. [Price 21*s.* net.]

The Problem of the Obelisks. By R. ENGELBACH. London: T. Fisher Unwin, Limited. [Price 9*s.* net.]

Practical Mathematical Analysis. By H. Von SANDEN. With examples by the translator, H. LEVY, M.A., D.Sc. London: Methuen and Co., Limited. [Price 10*s.* 6*d.* net.]

The Law of the Car and Every Motorist's Own Lawyer. By L. G. REDMOND-HOWARD and HAROLD CRANE. London: Percival Marshall and Co. [Price 2*s.* 6*d.* net.]

Mercantile Calculation Tables, Relating to Metals, General Merchandise and Freights. Compiled by A. KIRCHNER. London: Crosby, Lockwood and Son. [Price 3*l.* 3*s.* net.]

History of the Great War, Based on Official Documents by Direction of the Historical Section of the Committee of Imperial Defence. Naval Operations. Vol. III. *Text.* By Sir JULIAN S. CORBETT. London: Longmans, Green and Co. [Price 21*s.* net.]

Modern Electro Plating. A Guide Book for Platers, Works Chemists and Engineers. By W. E. HUGHES, B.A. London: Henry Frowde and Hodder and Stoughton. [Price 16*s.* net.]

Movable and Long Span Steel Bridges. Edited by GEORGE A. HOOL and W. S. KINNE. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

CAPE WIRELESS STATION.—Messrs. Dougall and Munro, Limited, have received the contract to erect the new wireless station at Klipheuvel, some 27 miles from Cape Town, according to *The South African Mining and Engineering Journal.* The station will have 16 masts of an average height of 830 ft. It will form a link in the Marconi circle and will transmit messages all over the world. A commencement has already been made on the buildings, and in about eighteen months one of the largest wireless stations in the world will be completed.

INDUSTRIAL NOTES.

MR. J. NICHOLSON, general secretary of the National Union of Vehicle Builders, has announced that following a vote, the Union has amalgamated with the Wheelwrights', Smiths' and Kindred Trades. A few local unions, including a London one, remain independent; the national coach-building trade, however, which covers all men engaged in the motor trade, in railway carriage works, tramway and omnibus construction, now comes under the one organisation.

We referred in former issues to the congestion in the South Wales docks owing to the time taken in loading coaling ships. The tippers and trimmers decided as an experiment, to work a third, night, shift to relieve the situation. They resolved a few days ago to discontinue this. The men so displaced have been absorbed into the day shifts, pending a joint conference of employers' representatives with the men's executive. The result of the new resolution is that the ports are gradually becoming congested again, a situation which may lead to decreased activity at the coal mines.

A national delegate conference of the Transport and General Workers' Union held last week-end at York, had under consideration the union's policy in the matter of the wages and conditions of the dockers. At the close a statement was issued saying that it was decided to submit proposals for the modification of the national agreement, so as to recover again in regard to wages the position that existed before the agreement of September, 1922, was signed. This meant the restoration of the last 2*s.* of the daily minimum, with proportionate advance for piece-workers. The daily minimum would thus be 12*s.* in the larger ports and 11*s.* in the smaller. The executive has been requested to draft a bill for the purpose, the bill to deal with a maintenance scheme and a guaranteed weekly wage.

The Midland Wages Board shows for the iron and steel trade for September and October a drop in the average net selling price of about 3*s.* 6*d.* per ton compared with the preceding two months, and, under the sliding scale, wages are reduced 2½ per cent. They are now 55 per cent. above the base rate. The drop in prices is accompanied by substantial increases in output. This applies to ironworkers in Staffordshire, South Yorkshire, Lancashire, Derbyshire and Wales.

The latest report issued by the London County Council gives under the heading, Highways Committee, particulars of recent tenders for the supply, delivery and erection of a 15,000 kw. steam turbo-alternator, condensing plant, &c., for the Greenwich power station. Some of the tendering firms and their prices were as follows:—

	Turbo-alternator.	Condensing Plant.
Oerlikon Co., Switzerland	42,964*l.* 6*s.*	12,805*l.*
Brown, Boveri and Co., Switzerland	43,837*l.*	12,786*l.*
Escher, Wyss and Co., Switzerland	48,610*l.*	16,619*l.*
Richardsons, Westgarth and Co., Ltd.	57,740*l.*	12,364*l.* 15*s.*
C. A. Parsons and Co., Ltd.	62,607*l.*	11,161*l.*

The general manager's estimate comparable with the tenders was 70,000*l.* for turbo-alternator and condenser complete. Messrs. Richardsons, Westgarth, in common with the other firms, submitted a number of alternative quotations. Of all the combinations submitted, the Highways Committee were advised that the alternative tender by Messrs. Richardsons, Westgarth, for their own two-cylinder turbine, with Parsons' alternator, and their own condensing plant requiring two condensers, amounting in all to 77,466*l.* 15*s.*, was the most advantageous. This set was specially economical in steam, and showed a saving of a very considerable amount per year, even after taking into account the department charges on the higher capital cost, as compared with the lower tenders. The Highways Committee proposed, therefore, with the concurrence of the General Purposes Committee, to accept this alternative tender of Messrs. Richardsons, Westgarth.

According to *The Iron Age*, New York, figures of the National Industrial Conference Board show living cost at 64·1 per cent. above July, 1914, based upon the budget of the average wage earner. This compares with 63·4 per cent. excess in September. The increase is due to rises in food and clothing prices. Much of this increase is attributed to steady advance in wage rates, whereby among other readjustments in the metal trades fixed wages for certain skilled labour is on a new range of 125 dols. to 150 dols. per week.

It was stated last week at the annual ordinary general meeting of the Cargo Fleet Iron Company that the problem of an increased use of suitable home ores was one that could only be solved by the railway companies. The cost of Northamptonshire raw stone was about 3*s.* per ton in trucks, whereas the railway carriage to the Cargo Fleet works near Middlesbrough was 8*s.* per ton in owners' wagons. The American iron trade was dependent upon Mesabi ores. The present inclusive charge for the conveyance of iron ore from the Mesabi mines to the works at Pittsburgh—a distance of over 1,000 miles—at the present rate of exchange, was 13*s.* 10*d.* per ton. This figure included railroad transport from the mines to port of shipment, freight down the Lakes, and the railway carriage from the Lower Lakes ports to Pittsburgh. It also included the provision of steamers and trucks, and the cost of loading into steamer and discharging. It must also be remembered that the transport of this ore involves no less than four operations, in discharging from trucks into steamer, and at the Lower Lakes port discharging from steamer into trucks. In contrast with this, the railroad carriage on raw stone from Northamptonshire to Tees-side—a distance of 180 miles—was no less than 8*s.* for haulage alone. This figure did not include the provision of trucks, which must be supplied by owners, nor did it include the cost of loading or discharging, which had also to be borne at owners' expense. The iron trade of Westphalia was largely dependent upon the ores of Meurthe et Moselle and Alsace-Lorraine, which were no nearer to the works than Northampton was to Tees-side; and if the railway companies would provide suitable wagons for the trade and lower rates for the conveyance of the ore there was no reason why foreign ore imports into our own country should not be largely reduced and their places taken by native ores. It would pay the railway companies to carry iron ore in trainloads at a very low special rate in order to increase the output of pig iron and steel, from which they would obtain carriage on all the other raw materials and finished products; giving them a larger revenue.

At the same meeting of the Cargo Fleet Iron Company the following statement was also made: It was estimated that, whereas, in 1913, 60 per cent. of the pig iron of this country was made from home ores and 40 per cent. from foreign ores, in 1922, when the pig iron made amounted to only half its pre-war volume, the percentage from home ores had fallen to 55 per cent. and that from foreign ores had risen to 45 per cent. If the home ores had maintained the same relative position, even with the reduced make of pig iron, nearly 1,000,000 tons more of home ores would have been used.

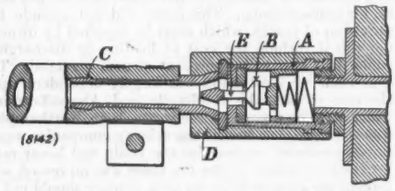
SOUTH AFRICA AND AIRCRAFT.—The Federation of British Industries report that foreign aircraft making a passage through, or over, the Union of South Africa, which infringe in whole or, in part, any invention, design or model protected in the Union, are liable under the Union Aviation Act, No. 16, 1923, to detention until a sum of money is deposited in respect of the alleged infringement. In default of agreement the amount will be fixed by the Court.

THE TIMBERING OF METAL MINES.—There is on the whole very little literature devoted to mine timbering, and it is very difficult for the young engineer to acquire knowledge of systems in use except those coming directly within his experience while under training. To such men, when their training is ended, and they find themselves transferred to some totally new sphere of work, the problems presented may, for geological and other reasons, be quite different from those to which they had become accustomed. To these and others, we may recommend a pamphlet of some 72 pages, entitled "Timbering of Metal Mines," and issued at the modest price of 25 cents by the Department of the Interior, Bureau of Mines, Washington, D.C., U.S.A. This pamphlet is liberally illustrated by means of photographs and line blocks, showing different types of framing, the behaviour of timber and frames under pressure and the best way of dealing with various situations. The little work is very complete and goes even into the structure of wood, the preservation of timber, knots to be used in handling it, &c.

JAPANESE PATENTS.—All the registers and almost all the documents at the Japanese Patent Office having been destroyed in the recent earthquake, temporary rules and regulations have been drawn up to meet the situation. These provide, *inter alia*, that in any case where application was made before September 1, 1923, for the prolongation of a patent right and no decision was received, copies of the application and other relevant documents including a written statement declaring the original date of application, shall be presented to the Patent Office not later than December 31, 1923. Any person who has obtained the registration of a patent, utility model, design or trade mark, should apply for recovery of registration before October 31, 1924, when his right will maintain its order in the original register. In view of the importance of this matter to members of the Federation of British Industries, telegraphic inquiries are being made with a view to eliciting further information, and in particular as to whether any expense involved might not be considerably reduced by effecting re-registration through some central organisation. Applications can only be made through a representative resident in Japan.

ADAPTER COUPLING FOR PNEUMATIC HOSE.

The extended use of compressed air in boiler shops, machine shops and other industrial establishments, has caused a good deal of attention to be paid to the services by which the air supply is brought to the tool or machine to be operated. A leaky air system can result in an enormous waste of power, and having regard to the conditions under which pneumatic power is installed and used, it is of the first importance that the fittings shall be simple and thoroughly reliable. There are on the market many devices for coupling an air hose to the fixed service connection in the wall of the shop or elsewhere, but a new one with several useful special features has been brought out by the Rothschild Engineering Company of Acton-green, London, W.4. This, which is put on the market under the name of the "T. and O" adapter coupling, is illustrated in section in the accompanying figure. The portion of the apparatus permanently fixed to the wall.



or other support, terminates in a tapered brass plug A, which is cut with a couple of turns of square thread at its rearward end. This plug contains a conical valve B which is pressed to its seat in the end of the plug by the air pressure in the pipe, assisted by a light helical spring.

The end of the rubber hose is permanently clipped to a steel nipple C, on the end of which is mounted a brass adapter sleeve D bored taper and screwed internally to fit over the fixed plug A. The adapter sleeve D is swivel jointed to the nipple so that it can be rotated without twisting the hose, and a rubber gasket covers the end of the swivel joint. The end of the nipple is perforated with air ports and carries a central projecting pin E, which when the sleeve D is screwed on to the plug, pushes the valve B off its seat and admits air to the hose pipe. The tapered bore of the sleeve makes an airtight fit over the plug, and the rubber gasket prevents leakage round the swivel end of the nipple. The sleeve is knurled on the outside so that it can be easily connected or disconnected by hand without the aid of any tools. The tapered bore prevents the coupling working loose with any ordinary vibration, and the fact that connection may be instantaneously effected and air automatically turned on at the same time makes the device particularly handy in use.

The agent for the coupling is Mr. William A. Rollo, of Members-mansions, 36, Victoria-street, London.

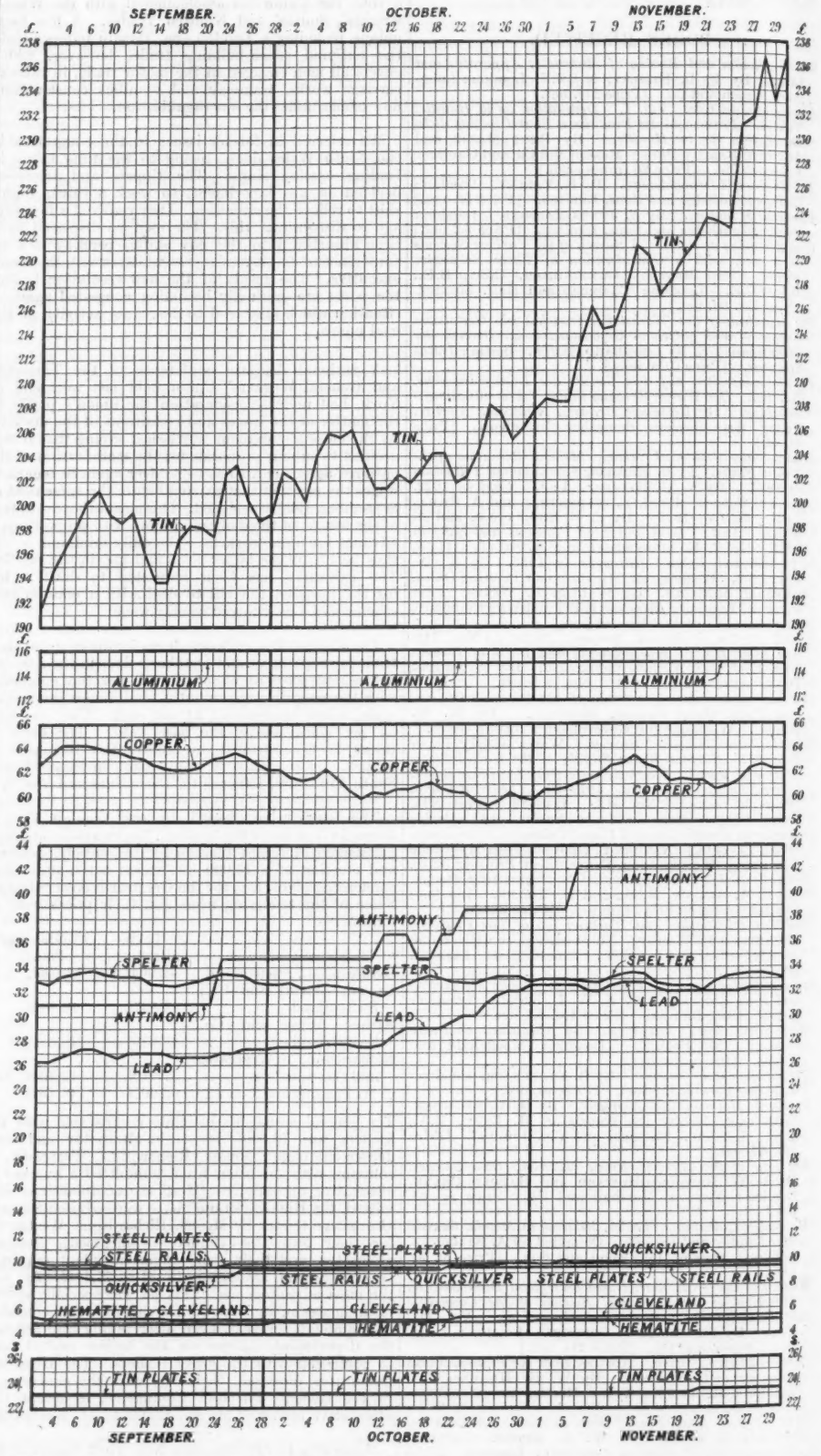
Contracts.—The Vickers-Spearing Boiler Company, Limited, 20, Kingsway, W.C. 2, were, last week, successful in securing a contract for the second section of four large water-tube boilers of the Spearing type for the Leicester Corporation Electricity Works extension.

Disposal of German Ammunition.—In our issue of July 27 last on page 119 we described some of the methods employed by Messrs. F. N. Pickett and Son in carrying out their contract for the disposal of ammunition left on the dumps in Northern France and Belgium at the termination of the war. We now learn that during the last two years some 14,000 tons of German ammunition of a very dangerous character, recovered from the devastated regions and the forward areas in the North of France, have been passed through the port of Dunkirk and dumped in the sea almost 4 km. from the shore. This work has been carried out by the Maison Victor Rose of Dunkirk, acting in conjunction with Messrs. Pickett, and it is satisfactory to note that no accident has occurred either during the dumping operations or in connection with the transport of the material by the Chemin de Fer du Nord.

The Burmeister and Wain Diesel Engine.—A director of Messrs. Burmeister and Wain's Shipbuilding Company, Copenhagen, recently stated that there are now 126 motor vessels afloat fitted with Burmeister and Wain Diesel engines. A number of these have been built by licencees in other countries. The Copenhagen firm has built 36 motor vessels and engines for 16 additional vessels built elsewhere. In 1912—when the first large motor vessel, the Selandia, was fitted out—the engines were of 2,500 h.p. capacity, which contrasted with 20,000 h.p. engines for the new Swedish America liner Gripsholm. Diesel engines on the Burmeister and Wain principle of the same capacity are being built in England for liners. It is pointed out that the original Selandia engine does not appear to be showing any serious wear and tear, and it would appear that when a motor vessel is worn out the engine could be taken out and used in a new vessel and operate practically as well as a new motor.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE PUBLIC WORKS, ROADS AND TRANSPORT CONGRESS.

(*Concluded from page* 679.)

THE QUALITY AND COMPOSITION OF TOWN'S GAS.

WE now conclude our account of the proceedings of this Congress by dealing with the meetings held on the last two days, viz., Wednesday, November 28, and Thursday, November 29. Two conferences were held simultaneously on the morning of the 28th ultimo, one of which was arranged by the Institute of Public Administration and was devoted to the discussion of a paper by Mr. A. T. V. Robinson on the organisation and equipment of an accounting department. At the other conference, which was arranged by the Institution of Gas Engineers, the chair was occupied by Mr. S. Tagg, and the first paper taken was one by Mr. H. E. Bloor, entitled "The Quality and Composition of Town's Gas." In this paper, the author pointed out, at the outset, that a right understanding of the issues involved in a discussion of the quality and composition of gas demanded some acquaintance with the history of the statutory control of the industry, and his communication therefore took the form of an historical survey of the subject up till the passing of the Gas Regulation Act in 1920. He detailed the steps leading to the change from the illuminating-power standard to the calorific-value standard, explaining how this had been influenced by circumstances arising out of the war. The provisions of the 1920 Act were also dealt with, reference being made to the considerations underlying the choice by the undertakings of the calorific value of the gas they intend to supply. In connection with the composition of town's gas, the paper dealt with the extraction of sulphur compounds, the proportions of inerts, of hydrogen, of methane, and of carbon monoxide, the latter being treated at some length, while the presence of unsaturated hydrocarbons and naphthalene was also considered. Appendices to the paper showed the relation between illuminating power and calorific value of gas supplied by various undertakings; the number of deaths from accidents, including coal-gas poisoning; the amounts of oxygen and air required for the combustion of various gases; the composition of various mixtures of coal gas and carburetted water gas, and of coal-gas and producer-gas; and typical analyses of town's gas supplied by various gas undertakings. In connection with the accidental deaths due to coal-gas poisoning, we may mention that the data given in the paper show that these amounted to 2·4 per million of the population for England and Wales in 1921, the figure given being less than one-third of the corresponding one for bathing fatalities.

The discussion on this paper was opened by Dr. R. Lessing, who referred, in the course of his remarks, to the presence of carbon monoxide in gas. It did not matter, he said, what proportion of carbon monoxide was present so long as the gas was used for its normal purpose, and was not allowed to escape from the pipes. There was no danger from this cause, and he thought the public should be reassured. The gas itself, he pointed out, was a relatively minor product of the gas industry, but the coke, tar, ammonia and other by-products were of vital importance to the domestic and industrial life of the nation. Alderman W. Muirhead, of Liverpool, on the other hand, expressed the view that the proportion of carbon monoxide in town gas should be legally restricted. Mr. George Evetts suggested certain modifications and additions to the historical statements in the paper, and expressed the view that the passing of the Gas Regulation Act had been amply justified by results. He also pointed out that the matter of the calorific value was not only a question of manufacture but was largely influenced by the problem of distribution.

The author, in the course of his reply to the points raised in the discussion, referred particularly to the presence of carbon monoxide in gas. The statistics in his paper, he remarked, served to show that gas was extremely safe. Carbon monoxide was of great value to the community in that it enabled a cheap gaseous fuel to be supplied, and the advantages of such a fuel from the standpoints of health and economy were more than sufficient to balance any slight risk there might be. The gas companies, however, were very anxious that the public should have no cause for complaint, and did their utmost to reduce the number of casualties from this cause, which, as he had shown, were already very low.

POSITION OF MAINS IN PUBLIC HIGHWAYS.

The second communication at the morning conference was by Mr. Stephen Lacey, and dealt with the positions of mains in public highways. In introducing his subject, the author stated that the weight of the gas distributed by the underground mains of the three Metropolitan gas companies amounted to about 1,000,000 tons per annum and that some 4,000,000 tons of coal would have to be transported over the surface of the roads to replace this quantity of gas. Dealing with the positions of service mains, the author said it was generally agreed that these should be laid under either footway in roads in urban districts. It was not, however, practicable to lay down a hard and fast rule as to the conditions which would warrant such mains being laid in duplicate. In some cases it might be possible to lay trunk mains under the footways, but there was less objection to laying these under the carriageway since it was rarely necessary to open them up. The author's experience led him to state that the depth at which a main is laid is of secondary importance, the solidity and uniformity of the bed upon which the pipe lies having the greatest influence upon its stability under stresses due to vibration, &c. Subways, he said, could only be built economically under special conditions in the case of new roads, since, with existing roads already congested with mains, the construction of a subway would involve additional expenditure for diverting the mains while the work on the subway was in progress; the cost would thus be prohibitive. The settled policy of all progressive undertakings owning mains under public thoroughfares was to take every opportunity afforded by the repaving works of road authorities to overhaul and modernise their systems, new mains then being laid under footways wherever possible and superfluous mains and service pipes under carriageways being thrown out of use. The importance of ensuring that this work should be carried out thoroughly and expeditiously was becoming more generally realised, and this, being so, the co-operation between roads authorities and the undertakings, which was essential to successful working, followed as a matter of course.

Mr. W. J. Liberty, speaking in the discussion on this paper, expressed the view that as road surfaces were now usually hermetically sealed by heavy concrete foundations, some considerable time might elapse before leaks were discovered. He also referred to the congestion of underground mains in city areas and emphasised the utility of pipe subways, which he said should be constructed wherever possible. Mr. A. H. Collins thought the depth of mains was a matter of considerable importance in protecting them from the effects of traffic. Mr. B. R. Parkinson strongly advocated the use of steel pipes in place of cast iron, and Mr. E. Worrall pointed out that the transport of 4,000,000 tons of coal, which the author had stated was obviated by the transmission of gas through underground mains, represented an almost negligible proportion of the total street traffic of London.

In reply to the discussion, the author stated that his experience indicated that escapes from pipes under hermetically-sealed roads were more easily located than was formerly the case and added that the damage to the pipes was now reduced owing to the improvement of the road surfaces. He agreed with Mr. Collins that the depth of mains was a factor in the question of leaks, but it was not the chief factor; the nature of the foundation was of the greatest importance. In connection with the use of steel mains, the author stated that the question of corrosion was an all-important consideration, adding that experience with wrought-iron service pipes was not such as to encourage the extensive use of steel mains.

LEAKAGE CURRENTS AND ELECTROLYSIS.

The afternoon conference, which was arranged by the Incorporated Municipal Electrical Association, was devoted to the discussion of a paper by Mr. Charles Raphael, entitled "Electric Strays." The chair on this occasion was taken by Mr. S. E. Britton. The paper first mentioned that electric strays might be divided into three categories, viz., leakage of return current from the rails of tramways and electric railways; leakage from electric light and power mains; and leakage from electric installations in buildings. Of these the first was the most important and had been the cause of considerable damage to gas and water pipes by electrolytic action in the United States and Germany. In this country, however, the Board of Trade regulations limiting the permissible pressure drop on the rails, and the potential difference between rails and pipes, had largely eliminated the trouble, but it was important that the precautions should not be relaxed. No cases of electrolysis had been reported from railway and tramway lines such as the Underground Railways of London and the London County Council Tramways, in which insulated returns were employed. For electrolysis to occur it was necessary for the pipe to be carrying a current, and for the current to leave the pipe and flow into the ground. Corrosion would take place where the current left the pipe, and this would usually be near the generating station or sub-station end of the line, or near a negative feeding-point. The paper discussed the question of bonding the pipes to the rails with the object of preventing the current flowing from the pipe into the earth, the author stating that this course was not to be recommended. It was also undesirable to insulate the joints of the pipe, the best method of preventing electrolytic action, apart from keeping the pipes as far as possible away from the tram rails, being to coat the exterior of the pipe with bitumen and render the joints highly conducting by making them a good metal-to-metal fit. Electrolytic damage was unlikely to occur from leakage from electric light and power mains, although pipes might be burnt through faults in cables. In such cases, the damage to the pipe might occur at some considerable distance from the point of breakdown of the cable. A few cases of electrolytic corrosion of the reinforcement of ferro-concrete structures which had occurred were discussed by the author, who concluded that such action was extremely unlikely to occur under normal conditions. If the concrete were dry, electrolysis would be impossible, and if wet a fairly large voltage would be necessary to produce it.

Several speakers took part in the discussion on Mr. Raphael's paper, the most important contribution being that of Mr. S. C. Bartholomew, of the Post Office. The speaker stated that two or three cases of damage to telephone cables had occurred in connection with the Underground Railways of London, where the cables were laid under the tracks in moist ground. There were also several cases in which faults in electric light or power mains had caused breakdowns of telephone cables. The author's statement that little trouble had been caused by leakage currents in this country was true up till a few years ago, but in recent years there had been an increase in the number of cases. Last year, he added, 50 cases of damage to telephone cables had come under his notice, and this year some 60 cases had been reported; this was a serious matter as repairs were costly. Asked as to the relative proportion of the cases due to leakage from tramway systems and from electric light and power cables, the speaker said he could not say exactly; the cases in connection with tramways were certainly the more numerous, but the others could not be ignored.

In the course of his reply, the author said he would be glad to know what proportion of the cases referred to by Mr. Bartholomew had occurred in connection with tramway systems in which the Board of Trade regulations had been complied with. To a speaker who had inquired whether it was a wise precaution to protect reinforced concrete bridges from electrolytic corrosion by coating them with asphalt, the author said that this was unnecessary unless there was a reason for suspecting that the action was likely to take place. With regard to the Board of Trade regulations, the speaker remarked that the framing of these was in the nature of a step in the dark, and, at the present time, they must be regarded as the minimum requirements which should not be approached too closely.

ROAD CONSTRUCTION AND MAINTENANCE.

The whole of the last day of the Congress was devoted to the discussion of problems connected with the construction and maintenance of roads, the conferences being arranged by the Institution of Municipal and County Engineers. The chair at both the morning and afternoon sessions was occupied by Mr. W. T. Lancashire. The author of the first paper on the programme for the morning session, Mr. H. Collins, was unable to be present, but the paper was dealt with by his father, Mr. A. E. Collins.

Mr. Collins' paper described the various systems of road construction in order of their development, dealing first with water-bound macadam, objections to which, he said, were that it required frequent watering and was unsanitary. Surface tarring was useful and economical, but tar-macadam was a great advance on water-bound macadam by reason of its cleanliness and because of the small amount of dust produced. Something stronger and more stable than this was required, however, and the need had been met by coating suitable granites with a mixture of tar and bitumen. Still greater strength was obtained with grouted roads formed by laying and rolling dry macadam and afterwards grouting it up solid with bitumen containing fillers such as slate dust, graded sand, &c. The next stage in the development of road surfaces was the employment of carpets 1½ in. to 4 in. in thickness composed of a mixture of bitumen and broken granite, or other economical aggregate, of graded sizes, with a filling material so proportioned as to leave the minimum of interstices between the particles. Excess of bitumen, the author pointed out, resulted in too much plasticity and gave rise to deformation of the surface, while insufficient bitumen resulted in brittleness and disintegration. He recommended that the work of bituminous carpeting should be carried out by reliable specialist firms. Granite setts as a road paving were briefly dismissed as noisy and unsanitary, the author stating that wood-paving was the best surface for town streets carrying heavy traffic. In his opinion, creosoted pine blocks were the best form of wood paving. The author's experience with brick pavements had been unsatisfactory and he could not understand the good reports on this form of paving received from the United States. The paper included some notes on road foundations, in which the author called attention to the need for suitable side abutments

When a thoroughly hard bottom was obtainable, he considered concrete foundations unnecessary, and much less so, reinforcement. It was, however, the engineer's province to decide, in each case, whether to use reinforced concrete, plain concrete or to dispense with concrete altogether.

The second paper, by Mr. E. Worrall, reviewed the subject of road foundations and carpeting. In this paper the author expressed the opinion that cement concrete was the material that would best answer current and prospective requirements for the construction of road foundations and would sooner or later be adopted generally for that purpose. The composition and proportions of cement concrete were briefly considered, particular reference being made to the effect of the proportion of water used for mixing on the ultimate strength and permeability of the concrete. The author expressed the view that when any doubt existed as to the adequacy of the bearing strength of a road bed, or where weak places existed in the latter, the employment of suitable reinforcement in the concrete was justifiable and probably beneficial. The different forms of carpeting available were all briefly considered, and a full specification of the materials used, and work carried out in completing streets in granited rock asphalt for the Stretford Urban District Council, was given in the form of an appendix to the paper.

The two papers gave rise to a long and interesting discussion, in which 16 speakers took part. The space at our disposal, however, prevents us from giving more than a brief outline of it. The majority of the speakers were in general agreement with the authors, but several referred to the difficulty of obtaining a good foothold for horses on road surfaces suitable for self-propelled traffic. The general opinion appeared to be that horse-owners might assist by paying more attention to the matter of shoeing. Those speakers who referred to concrete foundations, generally agreed that reinforcement was necessary where the bearing power of the subsoil was poor. Mr. E. A. Slater spoke in favour of the use of granite setts for heavy traffic and referred to a method of laying them by bedding them into the concrete foundation before the latter had set. He also suggested that the setts should be placed longitudinally instead of transversely. The use of chalk for foundations was advocated by a few speakers, and Mr. W. A. Eley said he had found crushed tins an excellent foundation for roads carrying light traffic. Mr. N. O. Thorpe, however, expressed the opposite view, pointing out that the tins soon rusted away so that the foundation disappeared. Mr. G. W. Hamer queried the use of 40 per cent. of chippings in rock asphalt pavings as specified in Mr. Worrall's paper; he thought this proportion was too high. Mr. E. J. Goodacre suggested that legislation was needed in connection with the springing of heavy motor vehicles in order to reduce the damage to road surfaces. Mr. H. Boot advocated the use of brick pavings for roads and inquired as to the character of those referred to in Mr. Collins' paper as having proved unsatisfactory. Several speakers advocated further experimental and research work in connection with road problems.

The authors' replies to the discussion were rather brief owing to the lateness of the hour. Mr. A. E. Collins, replying for his son, said that the brick pavings referred to in the paper were laid in Norwich some 30 years ago. Blue bricks and brindled bricks had been used and these had not been able to stand up to the light traffic of back streets, much less to the heavy traffic of main streets. If, however, any improvement in brick manufacture had been made so that better bricks could now be produced, he would try them again. In the course of his reply, Mr. Worrall said he disagreed from Mr. Slater's views as to the use of granite setts. If the setts were laid in green concrete, as suggested, the road, he thought, would lack resiliency and would be very noisy. With regard to the use of tins for road foundations, he said they might be employed in the form of blocks as they came from the press, but it would not pay to use them in this way as they could be more profitably sold as scrap. To Mr. Hamer's query as to the proportion of granite chippings in rock asphalt pavings, he said he was satisfied that the proportion specified was correct. The main object of the chippings was to reduce the cost of the paving, but it also improved the wearing properties and appearance, and reduced the slipperiness.

The first paper presented at the afternoon session was one by Mr. F. Marsden, entitled "The Evolution of Roads and Transport thereon," and this was followed by a communication relating to the beautifying of roads, the author of which was Mr. J. L. Redfern. Both were subsequently discussed together. Mr. Marsden's paper, after briefly tracing the historical development of roads in this country, described what he regarded as the ideal cross section for a modern road. This included a central track 30 ft. wide for fast-moving traffic, two independent tramway tracks each 10 ft. wide and situated one on each side of the central track, a track 16 ft. wide adjoining the kerb on each side for slow-moving vehicles and vehicles stopping for the delivery of goods, and footways on each side 12 ft. 6 in. wide. There should be additional footways 5 ft. wide between the tramway track and the slow-traffic track and a grass verge 5 ft. wide, planted with trees and shrubs on each side of the central track for fast traffic. The total width of such a road would be 127 ft. Three main roads, each 100 ft. in width, which the author is at present constructing in the neighbourhood of Bradford, were described in the paper, one road having a single-line tramway track on each side, another having a double-line track in the centre, and the third having a double-line track on one side. From experience with these roads it was hoped to arrive at some definite decision as to the best allocation of road surface. The author emphasised the importance of making the tramway tracks independent of the carriageway and discussed the question of the position of the tracks, expressing the opinion that the best arrangement was that with separate single-line tracks on each side of the road. The advantages of railless electric road traction were referred to in the paper and the subject of the acquisition of land and buildings in connection with road improvement schemes was also dealt with.

Mr. Redfern's communication was a very useful and important one, though its subject matter hardly comes within our province. The paper dealt with road construction from the aesthetic standpoint and called attention to many points which if duly considered in the design would render a road much more pleasing to users while adding little or nothing to its cost. At the conclusion of his paper, the author expressed the view that, on account of their inflexibility, tramways have had their day.

Several speakers in the discussion on these papers spoke in favour of tramways, but the general opinion appeared to be that, when used on roads, the tracks should be situated in the centre rather than at the sides. Sir Henry P. Maybury, who supported tramways, appealed for a wider outlook on the traffic problem in general. He deprecated the application of the term "alien traffic" to that which did not originate or terminate in a particular district. All traffic, he said, should be regarded as belonging to the country as a whole. Sir Henry announced that the next congress similar to that then concluding would be held two years hence. He also mentioned that a certain amount of profit had been realised from the exhibition held in connection with the congress, and it was hoped that the sum so obtained would be used to form the nucleus of a fund for the foundation of a chair of highways engineering at one of the universities.

After the authors had briefly replied and the usual votes of thanks had been duly carried and responded to, the meeting terminated.

Methods of Curing Concrete Roads.—The question of curing concrete when in the form of road slabs laid *in situ* is one on which there is little quantitative information. In our contemporary, the *Engineering News-Record* (September 20, 1923), some tests are reported by Mr. H. J. Kuelling, of the Wisconsin Highway Commission, which are of interest in this connection. In these tests sample slabs were moulded in the road and removed for curing under various conditions for ultimate testing in an abrasion machine. Corresponding cylinders were also cast for crushing tests. Without going into all the details presented by Mr. Kuelling, we may state that the tests indicated that the best method of curing was the common one of maintaining over the concrete for a considerable period a covering of some inches of wet soil or dirt. The substitution sometimes adopted of wet hay or straw did not give such good results. In the case of concrete cured with calcium chloride, Mr. Kuelling points to the fact that the tests showed a noticeable fall in the modulus of rupture after 21 days.

The Colour of the Sea.—The intrinsic colours of the sea and of lakes have been ascribed to two main causes and to accessory features. The chief cause according to some was the high absorption by the sea water of yellow and red rays; others considered sea water essentially as a turbid medium, the suspended fine particles of which scattered principally blue rays. In a long memoir on the subject, submitted to the Scientific Institution of Moscow (reproduced in abstract in a recent issue of the *Physical Review*), W. Shulykin arrives at the conclusion that these two main causes suggested are both of importance, but that the colour depends chiefly on four factors, viz., selective absorption of light by the water, diffusion of light by very small particles (probably microscopic bubbles of air and occasionally other gases), selective reflection of light by fine dust, plankton and other solid turbidities, and admixture of the reflected light of the sky. Shulykin makes use of many of the spectroscopic measurements which O. von Aufsess had made in Alpine lakes; but he does not interpret them as showing that the scattering has little to do with the blue colour. His study of the influences of wind waves travelling over the surface is probably novel. By mixing a colloidal solution of rosin in alcohol coloured with rodalin blue and water, he successfully imitated the colour of sea water. He also points out that the intense blue of some mountain lakes is due to their receiving light only from the zenith, the lower portions of the horizon being shut off by mountains.

THE MANUFACTURE AND REPAIR OF HEAVY STEEL CASTINGS.

*The Manufacture of Heavy Steel Castings for Ships, with Special Reference to Stern Frames, Rudders, Shaft Brackets and Stems.**

By Hugo P. Frear.

The American Society for Testing Materials' specifications for steel castings permit steel to be made by one or more of the following processes: Open hearth, electric furnace, side-blow converter, or crucible. While each one of these processes has its advantages and disadvantages, there are some particular conditions or lines of work for which it is best adapted. All but the open hearth or Siemens-Martin process are better adapted for small castings or for foundries of limited capacities or where flexibility of product is desired. In the manufacture of heavy steel castings for ships the open-hearth process, on account of the large capacity of the furnaces, cheapness and high quality of the steel, is the only one used and is so specified by those classification societies which designate the process. Not only are there a number of processes for making steel, but there are various types of furnaces for making open-hearth steel, some of which are more desirable than others in meeting the numerous requirements and conditions as to capacity, materials available and degree of refining aimed at with which the steel maker has to contend.

The simplest type is the common stationary furnace. This is an enclosed chamber or hearth in which the flame is formed and reflected so as to strike the charge and melt it down. The furnace is built at a suitable elevation for tapping into the ladles. Below the furnace, sometimes directly under it but preferably at the rear, are two sets of regenerators built up of checkered brick work. The intensely hot waste gases leave the furnace on one end and, before entering the chimney, transit one set of regenerators until the brickwork is red hot. During this period gas and air transit the other set of regenerators, which have been previously heated in the same manner. After recovering a part of this heat from the regenerators, the gas and air enter and ignite at the opposite end of the furnace. Valves are arranged in the flues so that the operation or flow of the gases can be reversed. Thus the regenerators are heated up by the waste gases of combustion, first on one side and then on the other, and *vice versa*, heat is recovered by the gas and air alternately from either side and returned to the furnace. By this means it is possible to build up in the furnace within limits any desired degree of heat and a much greater heat than would be possible by direct combustion of the fuel. Throttling valves regulate the quantities and proportions of gas and air; otherwise the heat might easily become so intense that the lining of the furnace would be melted. On account of the intensity of the heat the lining of the furnace must be of a highly refractory material.

The furnace may be acid or basic, *i.e.*, with hearths lined with acid or basic material as the case may be. The sides and roof of both are lined with silica brick. The hearth of the acid furnace is first covered with silica brick and then built up to a thickness of about 20 in. with silica sand sintered or fused in layers about 2 in. thick. The hearth of a basic furnace is first covered with two or three courses of clay fire brick superimposed by two or three courses of magnesite brick. The thickness of the hearth is then built up to about 20 in. with magnesite or dolomite mixed with basic slag and sintered layer by layer the same as with the acid lining. The work is completed by charging a layer of open hearth slag and melting it in place. The character of the hearth lining fixes the kind of slag that can be carried in the furnace. This in turn determines the chemical reactions of the heat. Both the acid and basic slags are formed by the oxidation of the impurities of the charge. The acid slag takes up a certain amount of the ferrous oxide, while the basic slag, by the addition of lime, takes up a percentage of the phosphorus. Both form a blanket over the metal and protect it against oxidation from the flame and from the cooling effect of the air.

The usual procedure is to melt down pig-iron and scrap after which extract largely the manganese, silicon and carbon by throwing in iron ore. This results in the formation of gases within the metal, causing it to boil energetically. The melter, with a long-handled spoon, dips out a little metal from the furnace and casts small test ingots which are fractured and quickly analysed as a guide in adjusting the heat. These tests are taken at intervals until the composition aimed at is obtained. At the proper time Spiegeleisen or ferro-manganese is added in the furnace or ladle to restore the carbon and manganese for final adjustment of the chemical contents aimed at and to quiet the metal for pouring. In the acid process all of the sulphur and phosphorus are retained in the melt, or may even be augmented by sulphur from the fuel and loss of iron. On this account pig-iron and scrap, low in phosphorus and sulphur, is used in the acid process to make good steel. In the basic process dephosphorising and to a lesser extent desulphurising are accomplished. For this reason the basic process is the more available as both high and low phosphorus pig-iron and scrap can be used.

The ultimate end aimed at is securing, within specified limits, physical properties which experience has suggested as being the most desirable for the purpose. For these properties the reader is referred to the rules of the various classification societies, also to the specifications of the American Society for Testing Materials and United States Navy Department. The classification societies specify only physical tests, leaving it entirely up to the steel

* Abstract of paper read before the American Society of Naval Architects and Marine Engineers, New York, November 7, 1923.

maker to adjust the chemical content to secure a product that will meet these tests. Phosphorus is regarded as one of the more harmful elements in steel, and if it should greatly exceed certain limits, the steel is held to be likely to fail physically. Sulphur has little or no deleterious effect on cold steel. It does, however, if in sufficient quantity, tend to make it red short and pave the way for cracks in castings before they cool down to a black heat. On this account it is considered best to keep sulphur relatively low. In addition to specifying approximately the same physical tests, the American Society for Testing Materials and the United States Navy Department specify an upper limit for phosphorus and sulphur. Recent investigations by the Bureau of Standards, with the co-operation of several technical societies, manufacturers and consumers, have shown that the effect of high sulphur is not as serious as was once thought, especially in low carbon steels.

Without attempting to call attention to minor differences in physical tests under various specifications which are more or less uniform, it might, to save space, be considered sufficiently close to suggest the following as being typical.

(*a*) Tensile strength, 58,000 lb. to 78,000 lb.; (*b*) elongation, 20 per cent. to 15 per cent.; (*c*) reduction, 30 per cent. to 20 per cent.; (*d*) percussion, with hand hammer; (*e*) percussion, by dropping on hard ground.

The content to meet successfully the above requirement falls between the following limits: Carbon, 0·15 to 0·30; silicon, 0·05 to 0·60; manganese, 0·40 to 0·70; sulphur, 0·04 to 0·06; phosphorus, 0·04 to 0·06.

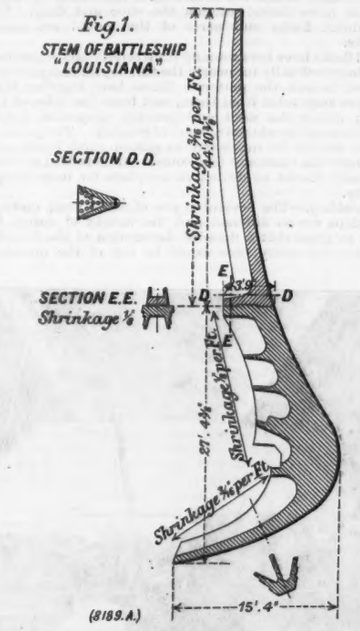
Physical properties of steel are affected by small changes in carbon, silicon, manganese, sulphur and phosphorus. The calculations for charging the furnace are based on the chemical properties of the materials which make it up, the amount of refining contemplated, and the characteristics of the steel aimed at. Carbon increases tensile strength and reduces ductility. Silicon increases tensile strength but adds to cost. As a deoxidiser it prevents blow-holes by increasing the solubility of the gas in the metal. It prolongs fluidity and gives the gas more time to escape or reach the risers. Manganese increases tensile strength, hardness, fluidity, reduces iron oxide and sulphur, and assists in counteracting sulphur and phosphorus, helps to prevent red shortness and ebullition during solidification. Sulphur tends toward making steel red short, where relatively high. Phosphorus makes steel cold short, increases tensile strength, reduces ductility and toughness and ability to stand shocks. Ability to stand shocks may be further reduced by the tendency phosphorus has to segregate. It may be added that all the metaloids segregate more or less, especially carbon, phosphorus and sulphur.

Great progress in the manufacture of heavy steel castings for ships in the past several decades has been made towards a reduction in the percentage of losses on account of defects or failure to meet specification. This is due in a large measure to advancement in the art of making steel, greater attention to design and the location of sink heads, more general use of chill plates, and more careful and intelligent work in the foundry. General foundry practice and the materials used, however, have changed but little. The problem of making steel castings over the above period was well understood. Steel foundry operations of moulding, core-making, pouring, &c., are very similar to those employed in the iron foundry. In the early days rolled and cast steel were equally unreliable on account of the poor quality of the product. The difficulties in making good steel castings are, and always will be, greater than making iron castings. These greater difficulties are inherent for several reasons. Fluid steel is necessarily hotter, cools more rapidly, shrinks more and contains more gas than iron. On this account it is necessary to give more careful consideration to design, to the preparation of the mould, and to use a more highly refractory sand.

Shrinkage.—As already stated, the melting-point of steel is higher than for cast iron and the shrinkage greater. Both the melting-point and shrinkage vary more or less inversely as the carbon content. It therefore follows that the lower the carbon content the higher the melting-point and the greater the shrinkage. Low silicon also increases shrinkage. As steel chills more rapidly than iron, this may also be attributed somewhat to the lower carbon content. It may be concluded, then, that a large part of the difficulties in making steel castings as compared with iron is directly due to the lower carbon content. At the risk of digressing it might be stated here that soluble gases in the cooling metal account largely for the other difficulties. This is due to low silicon which cannot be materially increased to reduce more of the gas except at great expense, on account of the price of ferro-silicon.

It is common knowledge that the shrinkage of steel is a variable quantity even in the same casting. This is more evident in long castings. There is no way to estimate accurately the shrinkage to allow at different points of the pattern. A stem casting is one of the most difficult to make so far as predicting correct shrinkage is concerned. If an order for a large number could be booked at one time, it would pay to cast one first to determine what the actual shrinkage would be. Fig. 1 shows the variation in shrinkage of the stem casting for the U.S. battleship Louisiana.

Shrinkage may be affected by variations in thickness and temperature of metal at different points of the mould. The temperatures are affected by thickness and by the way the metal is run in the mould. If the gates are not well distributed, the metal in some parts may be much cooler and almost ready to freeze by the time it has filled the mould. At the thicker parts of the casting the outer layer, next to the mould, chills quickly, while the inner layers are still fluid and hotter. When the second and hotter layer freezes on to the first layer, the latter is stretched, because there can be no sliding between the two layers and then the shrinkage is less than it ought to be. In some cases, if the mould does not yield, the metal in way of thin sections may be stretched and the shrinkage appear greater than if more free to contract. Theoretically, to reduce shrinkage, steel should be poured at the lowest temperature that it will run throughout the mould before it chills or becomes too cold to form a perfect bond, without creating cold shuts, where meeting from two directions.



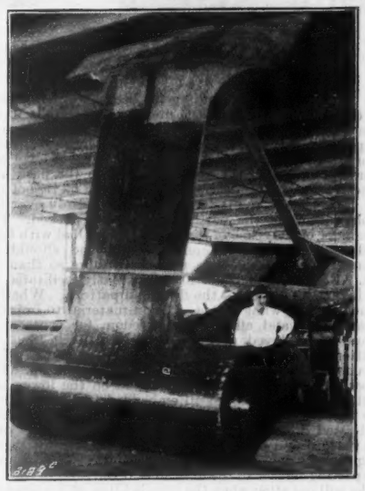


FIG. 2. PATTERN FOR SHAFT STRUT. U.S. BATTLE CRUISERS "CONSTELLATION" AND "RANGER." ESTIMATED WEIGHT, 42,000 LB.

Some authorities claim steel expands just before, and contracts after, solidification, but there is some question regarding what takes place in this respect during solidification. Reference will be made later to lugs on castings where cracks occur on both sides. Those on one side might be due to expansion just before, or at the time of solidification, and on the other side to contraction after solidification. Steel is said to shrink about ¼ in. to the foot, but in practice frequently varies from ⅛ in. to ½ in. per foot.

Design.—Many of the members of this society can look back to the time when stern frames, rudder frames and stems for merchant steamers were almost exclusively forged of iron. Both steamship lines and builders were slow to change from iron forgings to steel castings. Indeed some owners are still insisting on forged iron stern frames for single-screw steamers. There have been comparatively recent cases, where, for twin-screw steamers, owners have demanded forged iron rudder posts and yet accepted cast steel shaft brackets. It is a mistake to believe that internal stresses or serious defects do not occur beneath the surface of heavy iron forgings, especially if made of material of doubtful quality. Broken posts or shoes have occasionally revealed these defects. Poor material, frequently or necessarily used on account of the scarcity of good iron, in building up some of these forgings should be sufficient to convert the most sceptica to cast steel.

Under the great building programmes of the war, iron forgings in quantity were impossible. The art of making these forgings required greater skill than could be created for emergency war work. Not only were the plants equipped to make such forgings of small capacity and few in number, but good iron was practically unobtainable. The increasing use of cast steel and scarcity of good iron scrap offered little inducement for plant extension or for younger men to take the places of those who had grown old at the forge. Even most of these older men, like Othello, lost their occupation during the war and have disappeared. Iron forging, therefore, on account of the diminishing demand before the war, followed by the almost exclusive use of cast steel, has practically become a lost art.

Before the design for a large and especially a complicated steel casting is finally approved the traffic man, patternmaker, and moulder should be consulted. It sometimes happens that the capacity of the foundry is not the only factor which limits the size of the parts that can be conveniently shipped. Shipping facilities and clearances in tunnels and under bridges frequently necessitate making the casting in several parts or the elimination of foundries less fortunately located in this respect. In some cases where it was not practicable to divide the casting, or to ship it by rail, it has been necessary to have it manufactured at one of the few foundries so located that shipment could be made by water. The traffic man is able to furnish the data for determining the limit of dimensions and eligible foundries from transportation considerations. It may also be advisable to consider machine-shop facilities for both handling and machining.

The designer, patternmaker and moulder should have a thorough knowledge of shop conditions, shipping facilities, and the difficulties previously encountered on work similar to that in hand. The patternmaker and moulder should be acquainted with the action of the fluid steel in filling the mould, and in cooling so as to anticipate and guard against eventualities which experience only can predict. With the moulder not only the question of intricate design, but the planning and minutiæ in making up the mould is of vital importance. In the preparation of the mould it is not always the larger questions that demand the greatest skill but the small details. Fluid steel not only flows more slowly and cools more quickly than other metals, on account of its slow carbon content, but it cools more unevenly where there is marked variation in thickness. These conditions demand greater care in designing steel castings, as a safeguard against defects resulting therefrom.

In laying out the castings, simplicity should be kept in mind. Abrupt and sudden changes in shape, sections and masses should be avoided to the greatest possible extent. Where comparatively large masses of metal cannot be avoided they should be well tapered off into the thinner sections. Large fillets should be provided at all flanges and intersections. Flanges and webs or ribs should be designed with proper draught to facilitate drawing the pattern and pulling out the drawbacks. Experience has indicated that castings frequently come out overweight unless steps are taken to prevent it. To offset this, castings, in which weight saving is important, have deliberately been drafted lighter than specified. In recent cases, parts have been designed from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. under requirements, according to thickness, and on being checked are found to meet specifications. Castings such as propeller struts should have braces cast with the castings to keep them from getting out of shape while cooling.

Patterns.—Although the designer may have consulted the patternmaker and moulder before issuing the plans, it is often customary for the patternmaker and moulder to consult freely during the construction of important patterns. The foundry should receive the first consideration in deciding upon the methods of moulding and the best type or construction of the pattern for performing the work. It is false economy for the patternmaker to try and save a little money on the pattern at the expense of the foundry. With very few exceptions, it is more satisfactory to limit the number of core boxes and to make as complete a pattern as possible so that the moulder can see exactly what the casting looks like. Core boxes are generally necessary for cylindrical cores. There are very few moulds for large ship castings which cannot be handled in the foundry without any other core boxes.

In way of under-cuts or where sections of the casting are lightened up or cored out, so that they are open on one side and thus accessible to the moulder, he can then make the cores in place just as conveniently as they can be made in a core box. When cores are made in place they are called drawbacks. Where drawbacks are used, practically all the work is done on the floor by the moulder, and on that account more time is required to complete a mould. More men can be employed and time saved if the cores are made in boxes. The advantages of a full pattern and drawbacks more than offset the disadvantages in the final results. The drawback might be compared to a plaster cast. It fits exactly without juggling and ensures correct thicknesses of metal. A core made in a box is like making something to dimensions and expecting it to fit something else also made to dimensions. As a matter of fact, they do not always fit and have to be adjusted more or less in place, in which event the parts affected may either be too thick or too thin.

After the patternmaker and moulder have agreed

upon the type and method of making the pattern, they should jointly estimate the shrinkage which may vary somewhat at different points. Simple patterns, without undercuts, are frequently made in one piece. Most other patterns are made in halves. The manipulative possibilities in the foundry are so great and varied that exceptions can be found in most cases. As for instance, the ordinary A frame shaft struts (Fig. 2) shown in halves could be readily moulded if made in one piece.

The first operation in patternmaking is to lay out the shape of the pattern, full size, at the largest section or at the parting, on a substantial level floor or platform, making allowance for the shrinkage as determined above. Half the pattern is then built up on the full-sized lay-out on the floor. The wood should be well seasoned and straight. All the parts should fit before glueing or fastening. It is not good practice to force warped timber into place with screws or clamps, as the pattern may spring when released from the floor. After the first half of the pattern is completed it is turned over and the other half built on top of it. These patterns, though large, are often very fragile, and too great care cannot be exercised to frame and joint the wood to ensure the greatest possible strength. End grain and side grain, on the same face, should be avoided especially on a draught face, as one may shrink away from the other and damage the mould as the pattern is drawn. If patterns are shipped any distance, they should be properly braced and checked before shipping and again checked at the foundry.

Sand.—The facing sand used in making the mould and cores must be capable of resisting the high temperatures without fusing and sticking to the casting or spalling. It must be porous to facilitate the escape of gases generated in the steel while cooling, or by contact with moist sand. Gases trapped in the metal result in blowholes. There must be sufficient cohesion for ramming and stability for retaining form under the ferrostatic pressure of the molten metal. What might be termed a good sand aggregate is quite the reverse of the usual concrete aggregate, which is composed of many sizes of broken rock, gravel, sand and cement. Each smaller size helps to fill the interstices of the larger, and finally, in a perfect mix the cement fills the smallest interstices to make it impervious to water. An ideal sand, in order to possess the greatest possible permeability for the escape of gases, should be composed largely of grains of uniform size and of smooth, well-rounded form. It is obvious that a sand of this ideal character would not possess the necessary cohesion to retain its form without the addition of some finer material for a binder. It is also obvious that the smallest possible quantity of binding material should be used to give the greatest permeability. With the exception of a small amount of burnt sand, used only for economy, new materials should be employed.

Pure silica or crushed quartz sand (from 95 per cent. to 98 per cent. silica), mixed with a little burnt sand and core compound or clay, approximates these requirements. For large castings the facing sand is from 1 in. to 2 in. thick, according to the thickness of metal. The balance of the mould consists of heap or floor sand, together with material to help vent or render the mould more collapsible where necessary. Many different materials have been used to enhance venting and collapsibility, including cinders, coke, manure, straw, sawdust, &c. In order to secure uniformity, the facing sand is prepared by running it through a mixer. It is generally sufficient to mix the heap or floor sand by shovelling and sifting.

Cores.—There are comparatively few cores used in the manufacture of the large steel castings included under the title of this paper, which present as serious problems as those frequently encountered in designs requiring cores of greater area and length. Such cores, entirely surrounded by metal, and lighter than steel, are not only subject to the crushing effect on all sides, due to ferrostatic pressure, but may be subject to great bending stresses in resisting the upward pressure due to the difference in specific gravity. Under these conditions it is necessary to work in more effective binding material and suitable reinforcement in the way of arbours or steel rods. Cores of this character are common in cast steel shaft tubes. While these cores must be stronger than the mould, their collapsibility must be absolute. The shrinkage strains of the cooling metal wrapped around the core must either crush it or crack the casting unless the core can be removed soon enough after solidification.

Effective venting in cores is more important even than with the mould itself. The mould surrounds the casting on the outside, and the gases have more freedom to escape outward through the sand than inward through the cores. The only escape for the gases on the core side is through the core and out at the ends, and provision for this must not be neglected. For the facing sand of cores the best available quality, from bonding and venting considerations, should, therefore, be selected. The inner part must provide free venting to the ends and contribute both to strength and collapsibility. Drawbacks which are cores, properly speaking, are a somewhat different proposition. They are not entirely surrounded by metal but actually form a part of the outside of the mould. Reinforcing in the form of plates or grids is, however, required in drawbacks, so that they can be lifted and handled safely without breaking, but in other respects they can be constructed and vented more like the mould itself. Both dry and liquid core binders are used, the former being conceded to be the best for large cores.

Flasks.—The design, moulding methods, and pattern having been settled or approved, the next step in the routine of making castings is the assembly of flasks. All foundries accumulate a large assortment of flasks of various shapes and sizes or standard sections from which flasks, to meet all ordinary requirements, can usually be made. Cast iron, cast steel or rolled steel, on account of their durability and strength, are exclusively used in making up flasks for large steel castings. Some steel castings for ships are now so large and require such deep flasks that entirely new sections or complete special flasks have to be made. The drying of the mould is done more effectively in the oven, and for this reason it is preferable, where possible, to make the entire mould in flasks for ready handling. The upper part of the mould, including the top flask, is called the cope, while the bottom half is called the drag. If the cope is too large to handle in one piece, it is made up of several separate units. Sometimes in the case of special or complicated design the moulding is facilitated by using one or more flasks between the cope and drag. The additional flasks and parts of the mould are called cheeks.

All flasks have bars running transversely and sometimes also longitudinally for nearly the full depth, except where shaped to suit the pattern. These bars, together with gaggers suspended from them, and from the sides of the flask, retain the sand and prevent drop-outs during handling and breakouts at time of pouring. The joints of flasks should be machined to ensure good joints and minimise the chance of breakouts. All standard sections of flasks should be drilled to template for interchangeability.

Moulding.—The several types of large steel castings for ships are so different and the variety of design for each so great that a detailed description of the foundry practice for every case would be out of the question.

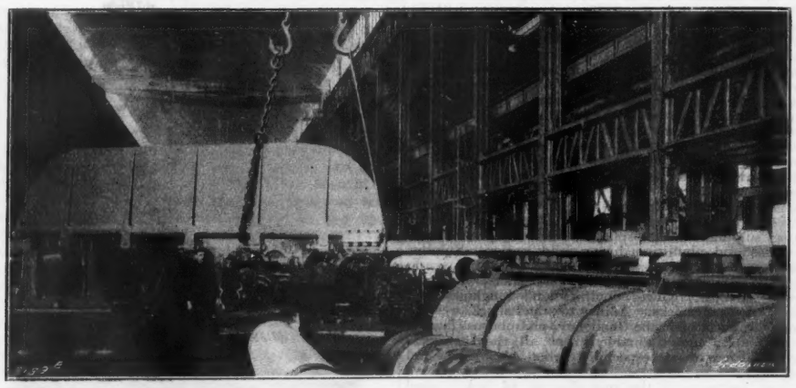


Fig. 3. Rudder Casting.

The simplest case of moulding for heavy work is where the drag or lower part of the mould is made in a flask. Where this is the case, the lower half of the pattern is temporarily held in place in the flask by joists or beams secured to both in the plane of the parting. A level bed is first prepared on the floor, after which the flask and pattern are, together, turned over and laid on it, bottom up. The facing sand is then applied uniformly over the whole surface of the pattern and firmly packed. The remainder of the space in the flask is then filled with floor sand and thoroughly rammed. The sand should be rammed as hard as possible, and much more so than for iron. Both of these operations are greatly facilitated by the inverted position of the flask and pattern. Whether or not, and to what extent, foreign material to improve collapsibility and afford more freedom for contraction should be employed, depends on the design.

After the work on the drag part of the mould is thus far completed it is turned over, or right side up. The upper half of the pattern is then laid on the lower half of the pattern which is still embedded in the drag, the two parts securely held in proper relation by substantial well-fitted dowels. The cope flask is then placed over the pattern and is also held in proper relation with the drag flask by dowels. A dry silica sand is sprinkled over the parting surface of the drag so that the sand in the two flasks will not stick when the cope is lifted off for drawing the pattern, &c. The application of face sand over the surface of the top half of the pattern, the filling of the flask and ramming, &c., is proceeded with the same as described for the drag. If chill plates are advisable, they are inserted along with the facing sand during the above operations.

The cope is now lifted and turned over and each half of the pattern drawn from its respective part of the moulds. Frequently particles of sand adhere to the pattern in drawing and make it necessary for the moulder to sleek or dress the mould. As the work progresses, large wire nails are inserted in the sand to make it more firm. The nails are spaced quite closely together and generally located in the copes, bottom of sprues and places subject to excessive cutting. Runners with gates to different parts of the mould and sinkheads or risers are arranged for the best flow and feeding of the metal and escape of gases. Chill brackets, as described elsewhere and shown on some of the illustrations, are also cut out by the moulder. If additional venting is advisable, especially at points where air or gas may be trapped, the mould is pierced at these points with a venting iron. Test coupons should be of the size, number and location shown on the plans. All dirt and loose sand should now be blown from the mould. Finally a wash composed of silica and molasses water should be deftly applied with a swab over the entire surface, giving it a smooth, hard finish when dry. When the mould is baked the molasses evaporates and restores the porosity of the sand. This completes the moulding operation, and assuming that the cores or drawbacks, where such are required, have been completed as described elsewhere, everything is ready for the drying oven. The temperatures of the drying oven should be raised slowly to about from 500 deg. to 900 deg. F. Thorough drying is very important and generally requires from 20 hours to 30 hours for very large moulds.

Flasks are seldom used, as described above, for the drag of the very large casting, or where the drying oven is not large enough to receive it. In such cases, the lower half of the pattern is bedded in the floor after a level bed has been prepared for it. When this procedure is followed the drag part of the mould is dried in place with a coke or charcoal fire; sometimes an oil or gas flame is used for drying. If the cope is too large to go in the drying oven, it can be placed over the drag and dried at the same time. After the mould and cores are thoroughly dried and the dirt again blown out, everything is ready for fitting up. The cores are placed in the mould and properly secured by chaplets where required. Chaplets are steel supports tinned or silver coated, and are used to help hold the cores in position, thereby ensuring proper thickness of metal. The cope and drag and cheeks, when they are employed, are then assembled and secured by clamps and bolts. Large moulds, in addition to being secured by bolts and clamps, are also weighted down to resist the ferrostatic pressure of the metal, which, of course, increases with the height of the risers. The pouring boxes, which are metal-lined with silica sand, are placed in position and the mould is ready for pouring.

Ladle and Tapping.—Pouring should be done as early as practicable after the mould is fitted up before it has had time to absorb moisture, and preferably while it is still warm. The getting ready of the ladles and the final adjustment of the heat should be timed for this event. Ladles of large capacity are made of plate steel-lined with refractory material and have a nozzle at the bottom through which the fluid steel is run into the mould. Some ladles have a second nozzle for use in the event of one sticking. The nozzles are opened or closed by a graphite or clay stopper. The stopper is secured to a vertical rod protected from the fluid metal by a sleeve or casing of refractory brick. The operation of the stopper rod is by hand through levers or other mechanism. Before tapping the heat the ladles are dried out and thoroughly heated so as not to chill the metal. After the heat is tapped it frequently happens that the steel is wild in the ladle in spite of the regular recarbonisers added in the furnace. To overcome this, a small quantity of aluminium is thrown in for more thorough deoxydisation. This suppresses ebullition, increases fluidity, and quiets the metal for pouring.

Pouring; Sinkheads; Runners and Gates.—Sinkheads, risers or feeders, as they are sometimes called, may be termed a necessary evil in the production of sound steel castings. The large percentage of scrap in the sinkheads and the expense of cutting them off is one of the important items in the cost of steel castings. The main function of sinkheads is to increase the ferrostatic head in the mould and feed fluid metal into the shrinkage cavities, created during contraction. It has already been stated elsewhere that the heavy parts of the casting should be at the top of the mould and that the sinkheads should preferably be located above them. It requires good steel and good foundry practice to produce sound castings, but these are not sufficient to guarantee uniformly good results when, on account of the design, nothing short of a miracle will do the trick.

If the design is such that the lighter sections are at the bottom and the pouring is done slowly from the top, the conditions would be ideal. The cooler metal and first chilling would be at the bottom and gradually work upward. Shrinkage cavities or pipe during contraction formed first at the bottom would be fed from the casting and also gradually work up to the top where the final feeding would come from the sinkhead. The simplest illustration of this would perhaps be the casting of an inverted cone with the sides projected upward to act as a sinkhead, and the pouring done slowly from the top. It is obvious that the metal at the inverted apex at the bottom would chill quickly and that contraction cavities

would be filled by the fluid steel higher up, either from the casting still fluid or by the metal being poured in slowly. As the cavities were continually being filled as they moved up or formed at each succeeding higher level, they would finally reach the top and the metal feeding them would come from the extended part of the cone, which, in this case, is the sinkhead.

In this example, not only is the hottest metal always on top ready to fill the slightest cavity below, but the sinkhead is so large that there is no possibility of it freezing at the neck before the feeding is completed. If the steel is all right, the chances of obtaining a sound casting are about 100 per cent. The sinkhead would probably weigh more than the casting, and the expense of cutting it off, plus the loss on account of the scrap, would make the cost per pound of the finished article prohibitive. The question of scrap of this kind is a serious one with the foundry, and every precaution is taken to keep it down to a minimum. For this reason, as referred to elsewhere, great judgment and experience are required in proportioning and locating the sinkheads. The size should depend on the amount of feeding required of them by the casting, but should not be so small that freezing at the neck might occur before the cavities were filled.

The above ideal procedure of pouring from the top and chilling from the bottom is common in making many small castings, but cannot safely be adopted in the case of large steel castings for ships. The danger of the metal cutting away parts of the mould in dropping or racing down to the bottom would be too great. For this reason the metal is poured into runners outside of and carried down to the bottom of the mould with branches, called gates, distributing it to several parts of the mould. Usually not less than two runners are provided for large castings. It will be noted that the hottest metal is run in at the bottom instead of at the top, as in the above ideal example, and that the cooler metal is filling the mould. On this account the metal must be run in more rapidly, in fact as rapidly as possible, so that the flow will not be interrupted by freezing before the mould is filled. When the mould is nearly filled, final feeding is completed by pouring through the sinkhead.

The runners should be proportioned to suit the weight of the casting, and the combined area of the gates should be at least a little greater than the area of the runner to avoid, as far as possible, chilling the metal before it gets into the mould. The bottom of the runner or sprue should be scooped out in the form of a bowl or pan and well nailed. This will provide a cushion for the metal to drop on and tend to prevent cutting away sand which would float up into the casting. The pouring of large flat castings such as rudders shown by Fig. 3, are frequently tilted up at the pouring side to speed up the running of the metal which is inherently sluggish as compared with iron. Scores of these rudders were cast in the tilted position by the Bethlehem Steel Company during the war.

(To be continued.)

THE DYNAMICS OF LEONARDO DA VINCI.*

By IVOR B. HART, B.Sc., A.F.R.Ae.S.

LEONARDO DA VINCI lived in the fifteenth and early sixteenth centuries (1452–1519). At Florence in his early days he came under the influence of such men of science as Benedetto del'Abbaco, Giovanni Agiropulo, L. B. Alberti and Toscanelli. In 1483 Leonardo migrated to Milan, where he took service under Ludovico Sforza in the capacity of consulting engineer, architect and sculptor. His chief scientific friendship during this period was with Fra Luca Paciolo, the famous mathematician. Leonardo's stay in Milan ended in 1499, and for some years we find da Vinci back again at Florence. In 1506, however, he accepted an invitation from Louis XII of France to return to Milan. He died at St. Cloud on May 2, 1519.

The reading of Leonardo da Vinci's MSS. has been a task of enormous difficulty, with which is honourably associated the names of a small band of enthusiastic students, chief among whom may be mentioned J. Paul-Richter, G. Piumati and C. Ravaisson-Mollien. Leonardo, from the time he was 20 years of age onwards, invariably wrote in a manner apparently calculated to confound his would-be readers. We may summarise the characteristics of his script under four heads: (1) He wrote from right to left after the fashion of the Semitic group of languages; (2) his handwriting was of the kind known as "mirrored," *i.e.*, reversed in a manner such as would be produced by looking at a normal script through a mirror; (3) he employed an elaborate scheme of abbreviations; and (4) he omitted the use of punctuation. It is accordingly much to the credit of the patient workers to whom reference has been made above that in spite of these difficulties the writings of this great genius of the Italian Renaissance have been rendered available to the world of science and letters generally.

It is proposed in this paper to consider the various contributions by Leonardo da Vinci in the field of dynamics—a study to which he referred as the "paradise of the mathematical sciences." His notes in this subject are found scattered throughout† his writings with a frequency and a persistence which show clearly the importance which he attached to it. They have at various times been considered by a number of students—notably by Grothe,‡ and Schuster§ (and more superficially by Seailles*), in the realms of the theoretical mechanics, and by Feldhaus† in the study of Leonardo's applications of mechanical principles to mechanism. At the outset it may be frankly stated that Leonardo suffered badly from the want of a precise and an accurate scientific vocabulary. All the modern ideas of force, motion, inertia, &c., are constantly to be found amongst the notebooks of our philosopher; but they are cloaked in a phraseology which is rarely precise, which is frequently puzzling, and which is seldom rigid. Yet condemnation for this would surely be most unjust. The motion of rigidity in scientific thought had no place in the fifteenth century. Looseness of expression is frequently the result of ignorance. A wealth of such looseness is not an unknown device as a cloak of assumed wisdom to hide such ignorance—a pseudo-learnedness, as it were. No one, however, can accuse Leonardo da Vinci of belonging to this class of writer. There is, however, the other side of the picture—the looseness of expression due to a sheer inadequacy of words to convey new ideas such as may occur to a writer who lives ahead of his times. It is to this class that Leonardo belongs. Many of his ideas, lost with the dispersal of his manuscripts, had to be rediscovered by others long after him. That these latter philosophers had the benefit of a later and a more complete terminology with which to state their discoveries is a fact that need neither detract from the credit due to Leonardo, nor blind us to the difficult paths of inadequate language through which he had to grope his way. Yet one other factor requires mention in this connection. Clarity of thought in the exact sciences could not properly come into its own until the test of experiment had been recognised and practised. Such pioneers of experimental science as Galileo in Italy and Gilbert in England, by inaugurating a new era in scientific research, paved the way for such an advance in accurate knowledge as to render absolutely imperative an expansion of technical vocabulary. Leonardo, more than one hundred years before Galileo, was most definitely an experimentalist. If the great Tuscan philosopher was indeed the "Father of the Experimental Philosophy," then da Vinci was its grandfather. "Experience (*ie.*, experiment,)" says he, "never deceives; it is only our judgment which deceives us, promising from it the things which are not in its power."‡ The appeal to experiment pervades all his writings on scientific topics. Small wonder, therefore, that his ideas and his discoveries outstripped his language. Living and thinking in terms of the late sixteenth and seventeenth centuries, he was yet compelled to express himself in the restricted language of the fifteenth. Vagueness of expression in the circumstances was inevitable. For these reasons, therefore, it behoves us to approach the notes on mechanics in no hypercritical spirit but to make due allowances by assuming for ourselves rather the role of the "man in the street" to whom ideas of scientific rigidity are foreign and are replaced by what he would call the "common sense of it."

LEONARDO'S DYNAMICS.

Force and the Principle of Inertia.—Immediate examples of the vagueness of language, but not necessarily of thought, occur in the various references contained in Leonardo's manuscript to the term "force." Mechanics being in effect the study of rest and motion, he was quite clear as to the fundamental importance of this concept of force, "Nothing whatever can be moved by itself," he tells us,§ "but its motion is effected through another. This other is the force." We have here at one and the same time his conception of the term force, and of what we speak to-day as the principle of inertia. He says that a body which is at rest cannot move of itself. It is important to note that he extended this to the case of the inertia of a moving body. Thus in his manuscript "On the Flight of Birds," in the course of a discussion on the sudden turning of a bird on to its side, he says, "And because all movement tends to maintenance, or rather, all moved bodies continue to move as long as the impression of the force of their motors remains in them."‖ Here, surely, we have a real flash of the scientific genius which forestalled Galileo (to whom the credit of the first enunciation of the principle of inertia is generally ascribed) by more than a hundred years. One can almost read in the above phraseology the classic first law of motion of the illustrious Newton as it is taught to-day in schools.

The Laws of Reactions.—The first was not the only one of the famous "Three Laws" which da Vinci either tacitly assumed or actually enunciated. It may reasonably be claimed that in its crudest sense—namely, that the effect of a force is proportional to the magnitude of the force acting—the second law of motion is more or less implied in da Vinci's notes as an instinctive truism.

The law of reactions, however, certainly does find a definite place in the MSS. Thus in the "Codex Atlanticus," in the course of a note on the parachute, we read, "An object offers as much resistance to the air as the air to the object."¶ Although the statement here takes the form of a particular application, it is clearly of a character which leaves little doubt as to the writer's definite appreciation of a general view of reactions. A similar reference is to be found later in the same manuscript.**

Force and Motion.—Turning to the relationship between force and motion, it is to be noted that da Vinci, following the teachings of Aristotle, laid down a series of enunciations* in this connection, a reference to which will show that in effect he regards the intensity of a mechanical action (*i.e.*, of a force) to be proportional to the velocity which it communicates to a mobile body. He had not reached the stage of realising that it was the acceleration which was in question, and not the velocity. Thus he says that "if a force moves a body in a given time over a given distance, the same force will move half this mass through the same distance in half the time."†

Falling Bodies.—Here, again, our philosopher just fell short of the realisation of an important truism which might otherwise have carried him far. In one MS.‡ we read as follows: "Why does not the weight O remain in its place? It does not remain because it has no resistance. Where will it move to? It will move towards the centre (of the earth). And why by no other line? Because a weight which has no support falls by the shortest road to the lowest point which is the centre of the world. And why does the weight know how to find it by so short a line? Because it is not independent and does not move about in various directions." Here [then] we get Leonardo's philosophy of the falling body in a nutshell, so to speak.

It was his study experimentally of bodies falling freely under the action of their own weight which led him to the idea of a uniformly accelerated motion. A note in MS. M. is very significant. "In the air of uniform density, the heavy body which falls at each stage of time, acquires a degree of movement more than the degree (of movement) of the preceding time."§ Here the idea of an acceleration is very clearly brought out. Interestingly enough, in the same manuscript another passage,‖ makes it quite clear that da Vinci was aware of the influence of the resistance of the air. He discusses the fall of two equal weights, the one vertically above the other, and notes that the distance between them steadily diminishes as they fall, until the bodies touch, his explanation being that owing to the screening effect of the lower body upon the upper one, the resistance of the air retards the motion of the former, but not of the latter.

Leonardo da Vinci definitely sought to discover the true law of accelerations for falling bodies. Unfortunately he failed to find a correct answer to his question. The correct law for falling bodies is, of course, that the fall is proportional to the square of the time, but Leonardo concluded that the function was linear. In MS. M. we find the following passage, a portion of which has already been quoted above: "In the air of uniform density, the heavy body which falls at each stage of time, acquires a degree of movement more than the degree (of movement) of the preceding time, and likewise a degree of velocity more than the degree (of velocity) of the preceding time. *Then to each quantity doubled in time, the length of the descent is doubled, likewise the velocity of the movement.*" From the sentence in italics, we see that da Vinci regards (1) the velocity as proportional to the time, which is correct [*cf*, the formula in kinematics, $v = g\,t$], and (2) the height of fall is also proportional to the time, which is incorrect.

Influence of the Earth's Rotation on Falling Bodies.—In the course of his investigations on the falling of heavy weights, Leonardo shows us a very brilliant example of sound scientific deduction. He dropped a number of heavy weights from the top of a tower, and noticed that they did not meet the ground absolutely vertically beneath the starting point. There was, he thought, a small easterly deviation, and this he proceeded to explain by its true cause, namely, the rotation of the earth on its axis. Actually, it seems impossible that in the relatively small fall of a body from the top of a tower, such a deviation is capable of observation. The probability is that Leonardo thought he saw it, and was thus started on a train of thought which led him to conceive why there must be such a deviation, so that it would never afterwards occur to him to doubt the accuracy of his observations. The passage in question occurs in MS. G. of the collection at the Institute of France, and is illustrated by a diagram similar to Fig. 1. "Let *a* be the body," says Leonardo in his note,¶ "which falls from the highest part of the sphere of fire** in order to come to the mid-point of the earth *m*. I say that this weight descending in a spiral will not leave the straight line which follows its way towards the mid-point of the earth. Because if the body goes from *a* in order to reach *b*, so will it go towards *b* and come to the position *c*. The point *a* in turning reaches *d*. If one now considers the position of the body, one finds that it is always found in the straight line which, originally at *a* and now at *d*, joins it to the mid-point of the earth at *m*. If the body goes further, towards *f*, then will the point *d* at the same time go to *e*. During the descent from *f* towards *g*, the rotation of *e* is brought into the position of *h*, so the body descends to the earth, always out of the starting point. This is an accumulative movement. It is a combination of a straight line and a curved line. It is a straight line because the body is always found on the shortest line which joins it from *a* to the centre of the earth. It is a curved line in itself and in every point of the path. Therefore a stone thrown from the height of a tower does not strike the wall of the tower until it reaches the earth."

Compounding of Forces and Velocities.—A point of

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* Abstract of paper read before the Newcomen Society, December 6, 1923.

† MS. E., Fol. 8v.

‡ H. Grothe, "Leonardo da Vinci als Ingenieur und Philosoph." Berlin, 1874.

§ F. Schuster, "Zur Mechanik Leonardo da Vinci," Erlangen, 1910.

* G. Seailles, "Leonardo da Vinci, L'Artiste et le Savant," Paris, 1906.

† F. M. Feldhaus, "Leonardo da Vinci als Techniker und Erfinder," Jena, 1913.

‡ Codex Atlan., Fol. 154B. See also Fols. 3B and 119B.

§ Ms. A., fol. 21v.

‖ Sul Volo degli Uccelli, Fol. 13 (12) v.

¶ "Codex Atlan.," Fol. 372B.

** "Codex Atlan.," Fol. 115B.

* "Mechanica Problematica,"

† MS. F, Fol. 26B; Fol. 51v.

‡ MS. Br. Mus., Fol. 175D.

§ MS. M., Fol. 44v.

‖ MS. M., Fol. 43v.

¶ MS. G., Fols. 54v and 55B.

** It should be remembered that the mediæval conception of the universe was that of the firmament around the *globus mundi* being surrounded by "elemental" spheres (moving successively outwards) of water, air, and fire, and beyond these the planetary spheres, then the sphere of the fixed stars, and finally the *primum mobile*.

immediate importance in connection with the preceding note is that we are here afforded a definite example in Leonardo's MSS. of the virtual compounding of two velocities or motions into a resultant single motion different from either of the constituent ones, Seailles* even goes so far as to regard it as an appreciation by Leonardo of the principle of the physical independence of forces and velocities, but this is perhaps straining the point beyond the stage of justification. The question, however, of whether or no we may fairly say of da Vinci that he knew that of which to-day we speak as the principle of the parallelogram of forces and of velocities, is full of both interest and importance. Probably it is most true to say that he knew something of this principle—that he was, in fact, on the fringe of its discovery.

In the manuscript "On the Flight of Birds,"† he gives another example, the two forces in question being the weight of a bird and the force of the wind, and although Leonardo neither constructs nor mentions a parallelogram, he at least definitely speaks of a resultant effect—he mixes his forces and his velocities quite freely—intermediate between the two.

The passage reads as follows :—

"(Falling.) The bird being in the act of falling in the direction of its open wings (Fig. 2) with a force of 4 and the wind which strikes it underneath with a force of 2 makes its course straight ; we will say, then, that the descent of such a bird will be by the mean line between the level of the course of the wind and the obliquity in which the bird was with the force 4. As : let the obliquity of such a bird be the line *a d c*, and let the wind be *b a* ; I say, if the bird *a d c* had a force 4 and the wind *b a* had a force 2, that the bird would not go in the direction of the wind (either) in *f* nor by its obliquity in *g*, but would fall by the mean line *a c* (Fig. 2) ; and one proves it thus."

The Resolution of Forces.—But what of the converse problem—that of the resolution of a single force or velocity into two components ?

In the course of a discussion on the motion of a weight sliding down an inclined plane, we read, "The weight which descends obliquely divides its weight in two different aspects. One proves it thus : Let *a b* (Fig. 3) move according to the obliquity *a b c*. I say that the weight of the body *a b* divides its gravity in two aspects, that is, according to the line *b c* and according to the line *m n*. Why and how much the weight is greater for one than for the other aspect, and what obliquity is that which divides the two weights in equal parts, would be in the weight of the body."‡

Motion Down an Inclined Plane.—It will be convenient to consider at this stage more generally the way in which Leonardo da Vinci dealt with the problem of the motion of a body down an inclined plane, a subject not attempted by any of his predecessors. He first considers a sphere on a horizontal plane, and points out that the perpendicular through the centre of gravity passes through the point of contact, there being no resulting motion. He next passes on to a sphere on an inclined plane, and shows that the vertical line through the centre of gravity lies on one side of the point of contact, and the body is driven down the plane by the action of a force. Leonardo realises that as the angle of inclination of the plane increases, so do both the distance between the point of contact and the vertical line through the centre of gravity (*i.e.*, the distance *o m* in Fig. 4), and the speed of movement of the sphere down the plane. He assumes (presumably from general observation) that this speed of movement is proportional to *o m*. "The greater is the distance between *m* and *p*," he writes,§ "the greater will be its speed." It would not, of course, be correct to speak of this motion down the plane as a "velocity," since, in fact, the motion is accelerated. So keen an observer as Leonardo would naturally have realised this fully, and as is seen from a further passage he uses the term "rapidity of movement." Leonardo's conclusion may be given in his own words. "The spherical body (Fig. 4) will take up a movement which is more rapid as its contact with the point where it runs will be more distant from the perpendicular from the central line. As much as *a b* is less than *a c*, so much will the spherical body fall more slowly down the line *a c*."‖ It is improbable that da Vinci, in the phrase "as much as *a b* is less than *a c*," had in his mind the idea of a difference. It is more likely he was thinking of the ratio of *a b* to *a c*.

Principle of Work.—We next turn to a consideration of Leonardo's writings regarding that of which we speak nowadays as the "principle of virtual velocities." It need scarcely be said at the outset that da Vinci never made use of the term "work" in the modern technical sense. Nor did he have any clear ideas as to the importance of the product of force and distance. Nevertheless he did appreciate the fact of a value in, and a measure of, what we might speak of as the achievement of a force. In MS. F., for example, we find a series of enunciations regarding forces, the last of which reads as follows :—"If a force carries a weight in a certain time through a definite distance, the same force will carry half the body in the same time through double the path."* There are other pronouncements in the same strain. They contain the germs—and, indeed, the live and very healthy germs—of the present-day principle of work, or the principle of virtual velocities. There is, in effect, a definite limit to the results of a given effort, and this effort is not alone a question of the magnitude of the force, but also of the distance, in any given time, through which it acts. If the one be increased, it can only be at the expense of the other.

There is to be found in MS. E. a beautifully clear application of this, in what is really a discussion on the mechanical advantage of a pulley system, illustrated in the note by a sketch (Fig. 5). "The powers," writes Leonardo, "that the cords interposed between the pulleys receive from their movement are between them in the same proportion as are between the speeds of their movements. The movements made by the cords on their pulleys, the movement of the last cord is in the same proportion with the first as that of the number of the cords ; that is to say, that if there are five, the first cord moving 1 yard, the last will move a fifth of a yard ; and if there are six, this last cord would have movement of one-sixth of a yard, and so on to infinity. The proportion which the movement of the force of the pulleys will have with the movement of the weights raised by the pulleys will be such as that of the weights raised by these pulleys with the weight of the force."†

Perpetual Motion.—Intimately linked up with this principle of work is the age-old myth of perpetual motion. If the principle of work be true, then the achievement of perpetual motion is impossible. On this matter, Leonardo had no illusions whatever. "Oh speculators on perpetual motion," he writes, "how many vain projects of the like character you have created ; go and be the companions of the searchers after gold";‡ Leonardo understood clearly the limitations implied by the principle of work. "If a wheel is moved for a moment by a quantity of water, and if this water is not added to either by flowing or by quantity, or by a greater fall, the function of this water is finished."§ With such lucid conceptions, we need scarcely be surprised, therefore, that Leonardo da Vinci writes "satanasso" against perpetual-motion comments in his notes, and that he consigns the "perpetual-motion" dreamers with a gesture to their true place among the ranks of the large army of necromancers, searchers after the philosopher's stone, and the other quacks of those times.

Impulsive Forces.—We conclude with a brief comment upon Leonardo's notes on the subject of impulsive forces. It is clear from his references in the "Codex Atlanticus,"‖ and elsewhere that he carried out a number of experiments both on the collision of bodies, and upon the recoil of spherical bodies from plane surfaces. His two chief conclusions are on the subject of the glancing impact of smooth spherical bodies on smooth planes. The first is that a blow applied normally to a surface has a greater effect on the plane than one applied at an angle, and that of two such inclined blows, the one whose angle of incidence is the smaller produces the greater effect The second conclusion is that for a rebounding body, the angle of incidence is equal to the angle of rebound. This is embodied in a note headed "Percussion," which reads as follows :—"The line of percussion (incidence) and that of rebound (reflection) are placed at the middle of equal angles. All blows struck on an object rebound by an angle equal to that of the percussion. This proposition appears clearly ; in effect, if you strike a wall with a sphere, it will rebound behind by an angle equal to that of the percussion. Thus if the ball *b* (Fig. 6) is thrown on *c*, it will return by the line *c b*, because it is constrained to fall on the wall *f g* at equal angles (*i.e.*, normally) ; and if you throw it by the line *b d*, it will return back by the line *d e*, and thus the line of percussion (incidence) and the line of rebound makes an angle on the wall *f g* situated at the middle of two equal angles, as one sees the angle *d* between the angles *m* and *n*."*

We have thus passed in review the chief contributions of Leonardo da Vinci to one of the two main branches of the science of mechanics. It is a fact that the field of statics claimed even a larger share of his attention. Nevertheless it must be remembered that whereas up till the time of Leonardo the history of mechanics was virtually a history of statics, the study of bodies in motion was almost entirely a new one. In this respect, as in so many others, our philosopher was a true pioneer. Dynamics had made such little headway since the Greek days of speculation on theories of gravity chiefly because the influence of the peripateticians was persistently against experiment. From this attitude, as we have seen, Leonardo broke away completely. Paying due respect to the wisdom of the ancients, who indeed influenced his views profoundly, he yet maintained the claims of the test of experiment. Naturally a genius, professionally an artist and an engineer, he was bound to break new ground. To those who, surveying the subject-matter of this paper, are tempted to regard the dynamics of Leonardo as superficial, we would answer that the wonder is not that he did so little, but that he accomplished so much. For of the whole of it, it may justly be said, that it constituted pure research in a virgin field.

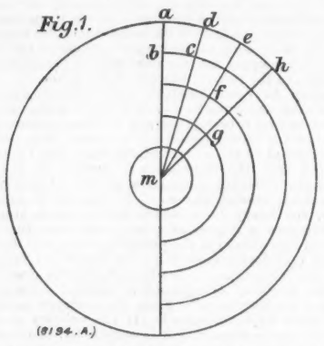

Fig. 1.

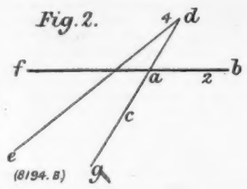

Fig. 2.

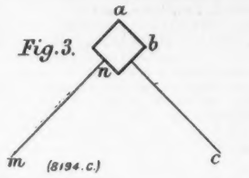

Fig. 3.

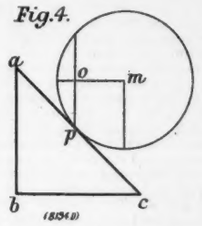

Fig. 4.

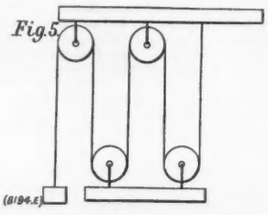

Fig. 5.

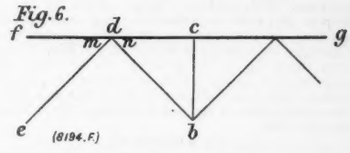

Fig. 6.

Glycerine-Water Quenching Medium.—In connection with an investigation by the Bureau of Standards of steels for the manufacture of precision gauges, an effort has been made, says *The Iron Age*, New York, to find a quenching medium intermediate between oil and water. Quenching curves were recently taken of specimens cooled in water solutions of glycerine. Such solutions answer perfectly, so far as the cooling rates at high temperatures are concerned.

Gas Producers of the Blast Furnace Type.—In gas producers of the blast furnace or liquid slag type the combustion is so conducted that a gas essentially consisting of carbon monoxide with about 1 per cent. of carbon dioxide and of methane and a small percentage of hydrogen is produced, together with an easy-flowing slag which can be tapped off. The idea is not new. Ebelmen tried such furnaces eighty years ago in connection with puddling works, and he found the addition of iron slag to the coke charge profitable. As recently reintroduced in Westphalia the producers are, according to A. Wilhelmi of Oberhausen in Stahl und Eisen, of November 15, short steel blast furnaces, up to 4 m. in width and sufficiently high to hold a coke charge of 3 m. thickness ; they are provided with tuyeres, but are closed on the top by an arch ; the walls are sometimes water cooled and iron clad. The advantages claimed are that a uniform gas is obtained even with intermittent working which causes no trouble, that big charges can rapidly be dealt with and the load may be varied within wide limits without changing the character of the gas. In comparative trials charges of from 15 tons to 65 tons have been put through the producer in a day. To realise the full advantages the production of iron should be combined with the gas production. For this purpose iron ore is added to the charge ; the reduced iron percolation through the slag keeps the slag hot and prevents its freezing, and the iron has its value. The process then becomes cheaper than with rotating grate producers which are more expensive in first cost. The charge should always be so regulated that a readily-fusible slag is obtained ; that condition being observed, the furnace may be charged also with coal. The charge should be granular, but not too small ; in any case the gas produced carries a good deal of dust which is the undesirable feature. Good results have been obtained in several installations.

* G. Seailles, "Leonardo da Vinci l'Artiste et le Savant," Paris, 1905, page 229.
† "Sul Volo degli Uccelli," Fol. 6 (5) R.
‡ MS. G., Fol. 75v and 76R.
§ MS. A., Fol. 52R.
‖ *Ibid.*

* MS. F., Fol. 51v.
† MS. E., Fol. 20R.
‡ MS. S.K. 112, Fol. 67A.
§ MS. A., Fol. 30R.
‖ "Codex Atlan.," Fols. 28, 47, 64, &c.

* MS. A., Fol. 19R.